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TECHNICAL LITERATURE

Vol. II. — SEPTEMBER, 1907 — No. 3

THE FALL OF THE QUEBEC CANTILEVER BRIDGE

ONE OF THE GREATEST ENGINEERING DISASTERS IN HISTORY

[We present herewith an extended abstract of the descriptive article and editorial comment on this appalling catastrophe appearing in the "Engineering News" of September 5, and prepared by two of its editors on the ground after an exhaustive examination of the ruins of the structure—an instance of reportorial enterprise rarely met with in specialized journalism. Through the courtesy of the journal mentioned we are enabled to accompany the text with many of the original illustrations.—Ed. T. L.]

The great Quebec Bridge over the St. Lawrence River, half completed, failed suddenly on Thursday afternoon, Aug. 29, 1907, and collapsed into a gigantic scrap-heap. It was 15 mins. before the end of the day's work, and 85 men were on the bridge. Eleven were rescued, more or less seriously injured. Of the 74 dead about 20 bodies have been recovered.

When the newspapers on the following morning spread the news of the terrible disaster to every corner of the country, thousands of engineers, as they read the story, were grieved and sick at heart. They felt not only horror at the fearful loss of life, sorrow and sympathy for their brothers whose professional and business reputations were dealt a cruel blow when that huge steel structure fell into the St. Lawrence, but also a sense of personal loss as well.

It could not be otherwise. Public confidence in engineers and engineering constructors and in the safety and reliability of their works is an asset of the whole engineering profession. To have this public confidence receive such a blow as this at Quebec is a loss almost incalculable. For decades to come, the Quebec disaster will be quoted, in public and in private, as an unanswerable proof of the unreliability of engineers and their works—of even the best engineers.

For it cannot be said in this case that the disaster was due to the work of incompetent men who posed as engineers. Often it has happened, where an engineering work has failed, that the failure has been traced to the blunders of some quack wearing the professional garb. But at Quebec the work was in charge of men of long experience and the highest professional standing; so much the more, therefore, must the profession bear the responsibility.

There is another fact which makes this disaster a peculiarly heavy blow to the engineering profession. Of all bridge structures in the country which were expected to be built with absolute safety and certainty, we take it, the Quebec Bridge is foremost. We know of no engineering structure anywhere whose failure would have been a greater surprise to the profession than this collapse at Quebec.

The fall of this bridge ranks with the greatest engineering disasters in history. In our impression, indeed, it is the greatest. The bridge was to be of unprecedented size. The highest acquirements of the bridge-builders' art were called into service for its construction. The most elaborately careful predetermination marked all stages of its erection as well as its design. Before it actually fell every one competent to speak would have said that failure was an engineering impossibility. Now, the 20,000 tons of steel, piled along the foreshore and in the river—some of it in 200 ft. of water—bears witness to its possibility.

The facts about the structure and its col-

FIG. 1.—SOUTH CANTILEVER ARM OF THE QUEBEC BRIDGE. FROM A PHOTOGRAPH TAKEN THE DAY BEFORE THE COLLAPSE.

lapse, as far as determinable in the two or three days available, are briefly as follows:

DESCRIPTION OF THE BRIDGE.

The Quebec Bridge, crossing the St. Lawrence about 9 miles above Quebec, where the river is nearly half a mile wide and 200 ft. deep in mid-channel, was to have the longest span of any bridge in the world—1,800 ft., exceeding the span of the Firth-of-Forth bridge by 90 ft. Like the latter, it is a cantilever bridge. Its total length is 3,240 ft., comprising two approach deck spans of 220 ft. each, and a cantilever structure 2,800 ft. long, made up of two 500-ft. anchor arms, cantilever arms of 562½ ft., and a suspended span of 675 ft. The clearance above high-water was to be 150 ft. for a distance of 1,200 ft. Two railway tracks, two electric car tracks, two roadways, and two footways were provided. The enormous dimensions and great live load made the bridge a huge structure in every sense. The main towers or posts, 315 ft. long between end pin centers, rose to a height of about 400 ft. above high water. The principal members were of phenomenal dimensions. The section of the compression chord 4½ × 5½ ft., and of the main tower post, 5 × 10 ft., exemplify this. In general the structure was pin-connected, employing rows of 15-in. eyebars for its top-chord chain and all other main tension members; the compression members generally had riveted connections, but the posts were pin-connected to the bottom chords and the latter were pin-connected to the shoes, resting on the 24-in. pin which carried the main post.

It was to form a very important link in the Canadian railway system; several railway lines were to connect with each other and the Grand Trunk Pacific, now building, cross the St. Lawrence over this bridge. Some of the principal dimensions, grouped in tabular form, are as follows:

Approach spans, each	220 ft.
Anchor arms, each	500 ft.
Cantilever span	1,800 ft.
Cantilever arms, each	562½ ft.
Suspended span	675 ft.
Width of bridge center to center of trusses	67 ft.
Depth of cantilever truss at portals	97 ft.
Depth of cantilever truss over main piers	315 ft
Depth of suspended span at center	130 ft
Clearance above high water for width of 1,200 ft	150 ft
Total weight of metal work	38,500 tons
Weight of heaviest single piece handled	140 tons
Longest single section shipped	105 ft
Maximum number of eyebars on one pin	36
Diameter of pins	9 to 24 ins.
Weight of main traveler fully rigged with its track	1,104 tons

The progress of the erection, put into words, is thus The piers having been built under a separate contract, the falsework for the south anchor arm was built in 1905, and in 1906 the entire south cantilever, i. e., the anchor arm and the cantilever arm, was erected. In the present season, 1907, the falsework for the north anchor arm was built. It had been intended to continue on the south side to erect the south half of the suspended span by means of the main traveler, a great outside-running gantry structure, weighing 1,100 tons, and large enough to embrace the highest portion of the 315 ft. tower-bent over the main pier. But the desire of the government to see the bridge completed in 1908, the tercentenary of the founding of Quebec, caused the contractor, the Phoenix Bridge Co., of Phoenixville, Pa. (who had also designed and built the structure and erection equipment), to start dismantling the main traveler so as to move it over to the north side and begin erecting the north cantilever. A smaller traveler, weighing 250 tons, and running on the top chords, was built for erecting the suspended span. This traveler was prosecuting the erection of the suspended span at the time of the accident.

Thus, no part of the north half of the bridge was concerned in the accident, but only the south half, which was nearly complete. The diagram, Fig. 2, shows the half bridge as it would be when completed. This diagram would represent the south half seen from the east side (called the right-hand side; a member of the east truss is denoted by the suffix "R" in the marking of the truss members; thus ALP3R is the lower section of main post 3 of the anchor arm, right-hand or east truss).

We have represented by another diagram, Fig. 3, the condition of the bridge at the time of its fall. Three sub-panels of the suspended span had been erected complete, lateral bracing included. The fourth panel was just begun; the bottom chord had been swung to place, bolted at its field splice, and at its forward end hung by slings from the overhang of the traveler. The lower eyebar diagonal, shown dotted, was on the bridge ready to be put in place. The separate eyebars composing it were clamped together and in slings for hoisting into position and pinning to the outer end of the bottom chord section.

The view, Fig. 1, taken on the day before the collapse, exemplifies the manner of progress.

POSSIBLE CAUSES OF BRIDGE FAILURES.

What could have happened to this towering fabric of steel to send it crashing into the river?

One rapidly canvasses the possible causes of accident to bridges under construction. Traveler failures are a prolific source of disaster to bridges under construction; but the traveler on this huge structure as much a matter of anxiously careful construction and handling as the bridge itself. Connections left partially riveted or otherwise unsecured are another prolific source of erection accidents; but in building this great pin-connected cantilever all the main members had to be erected complete as the work progressed; and there was no reason whatever for delaying full wind and sway bracing—as, indeed, it was not delayed. In some types of bridge structure there is chance for doubt as to actual stresses; braced arches, continuous girders, and suspension bridges are examples. But in a simple cantilever there is absolutely no chance for doubt as to stresses. Failures of hoisting apparatus, with fall of main members, have occurred in bridge erection; but they seldom wreck the whole structure and least of all would they be expected to do so on the outer arm of a cantilever bridge, nor at all in a structure of such massive proportions as that at Quebec.

Failing pier foundations wrecked a great bridge over the St. Lawrence at Cornwall, Ont., not many years ago; but at Quebec the piers supporting the huge cantilevers were founded in moderate depth of water and the supporting material was tested with diamond drills to remove the last fraction of doubt as to its reliability at great depth. The piers themselves were of high-class masonry; there was no reason in that region of Laurentian rock for using any but the soundest stone. Even if considerable settlement of a main pier were to occur while the cantilever was under erection, it seems inconceivable that it should set up such stresses in the superstructure as to cause its complete collapse without a moment's warning.

The usual causes of disaster in bridge erection seem, therefore, improbable as causes of the wreck at Quebec. We are led, therefore, to turn to other causes peculiar to the structure itself. The Quebec bridge was to consist of two great cantilevers, with their river arms connected by a suspended span 675 feet long. In erecting this suspended span stresses are, of course, produced in the cantilever greater than those due to the dead load of

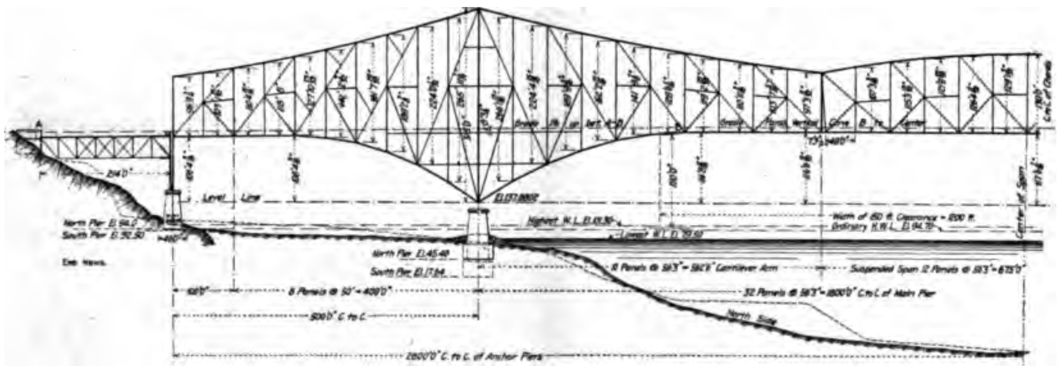

FIG. 2.—HALF DIAGRAM OF THE QUEBEC CANTILEVER BRIDGE.

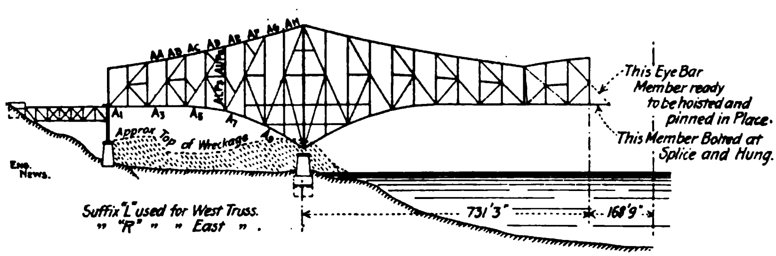

FIG. 3.—PROGRESS CONDITION OF SOUTH HALF OF QUEBEC BRIDGE AT THE TIME OF COLLAPSE, AUG. 29, 1907.

the span after it is connected. These erection stresses are, of course, accurately computable; but it is natural to wonder whether sufficient provision was made to sustain them. An error was made somewhere, of course, or the bridge would now be standing, and an error at this point may seem less improbable than an error of some other sort.

of safe stress on long steel columns of exceptional size is by no means perfect.

No one can doubt that the designers of this immense structure used the best data at their command in proportioning both tension and compression members to the loads upon them; but in using experience on lesser structures for the design of greater there is always a chance that some element unimportant in the small work will become important in the larger.

FIG. 4.—WRECKAGE OF SOUTH ANCHOR ARM, QUEBEC BRIDGE, SEEN FROM THE BLUFF WEST OF THE APPROACH SPAN.

The continuous line of the top-chord eyebars, showing clearly in this view, makes it apparent that no tension failure in the top chord caused the wreck. The lower section of the fourth intermediate post (between panels 7 and 8) of the left truss lies across the wreckage in the distance, with the joint at midheight of the post lying near the right top-chord eyebars.

Again, this bridge exceeded all structures heretofore erected in the size of its main members. It did this, necessarily, because of the length of the span. So far as the eyebars are concerned, equally large bars have been used on some other great bridges, and the heavier stresses in the Quebec bridge were provided for by using a larger number. In compression members, however, all previous sizes were necessarily exceeded. With the disaster at Quebec facing the profession, it is well to confess that our knowledge of the actual limits

THE APPARENT CAUSE OF FAILURE.

At the time this is written, at Quebec, on the fourth day after the wreck, the initial cause of the wreck appears to be the failure of some compression member in the anchor arm of the cantilever.

It is important to trace the analysis leading to this conclusion.

(1) Neither the main pier nor the anchor pier show the slightest sign of settlement or failure. They are monumental examples of high-class masonry, and, except for a few coping stones displaced or broken by the falling superstructure, both piers are, to all appearance, absolutely uninjured.

(2) The initial failure was not in a tension member. This is so important that we deem it well to show the proof in detail as follows:

a. Had a tension member failed first it would have snapped with a loud, sharp report or a series of reports as successive eyebars in a panel parted, which would have impressed every eye-witness. All accounts agree that the very first yielding was silent. The first warning was when the men felt the floor sinking beneath them.

b. Had a tension member failed, especially one of the top-chord members, the structure would have dropped instantly, like a falling body. The failure did not occur in this way. The hazy accounts given by eye-witnesses agree in the one fact that the collapse was rather gradual, at least in its first stages.

c. The eyebars of the upper chords of the anchor arm are intact, unbroken and still joined in a continuous chain, from the bottom of the anchor pier clear across the pile of wreckage, over the top of the main pier until they disappear in the waters of the St. Lawrence.

(3) The failure did not occur in a compression member of the river cantilever arm.

If a strut had collapsed somewhere near the end of the river cantilever, the rest of the structure shoreward would have remained standing, or, at least, would have very slowly collapsed progressively and probably not far toward shore. All accounts agree with the appearance of the anchor-arm wreckage in showing that the failure did not occur in this way.

(4) The failure was in a main truss member and not in any of the cross bracing.

All the wind and sway bracing was in place and fully connected, and there was no wind of any account when the bridge fell. Further, the trusses fell quite generally in the plane of their original position. The evidence of witnesses, moreover, speaks of no sidewise swinging, but only of the downward motion.

(5) The probabilities are against the failure beginning in a main post above the floor level. The time-keeper, who was facing the probable point of failure, had his first warning by feeling the floor yielding beneath him. A buckling upper post within a hundred feet or so of him would almost certainly have been seen.

(6) No indication as to the probable point of failure is to be seen in the fact that the wreck of the anchor arm on the foreshore lies slightly to the east of its original position. The center of gravity may be 8 to 10 ft., more or less, east of its location when the span was in position on the piers. But when the great height of fall is considered, it is impossible to conclude anything but that the structure, or its anchor arm at least, went down in perfect verticality.

Thus the probability is established, we think, that a compression member in the anchor arm, and that member not a post, but a section of the bottom chord, was the seat of initial failure.

At present the explanation of greatest probability is the failure of the ninth left-hand bottom chord. This explanation rests on one most weighty fact: Of all the bottom-chord sections of the anchor arm (all of which have been fairly well traced) there is only one that exhibits characteristic buckling distortion, and that is the ninth chord. All the others are bent and crushed, broken at the splices, cracked across, burst open, and most variously battered, but none has a well-defined buckle. The ninth of the left truss, however, is not merely buckled in indisputable manner, but it is doubly bent in a closely folded S-shape, and both its ends still lie practically in their original direction. Did this chord crush as a result of the fall? That event happened to all the posts, as our photographic views show strikingly, but not to the chords. The posts had the crushing endwise impact of the fall to withstand, but the chords only fell laterally. A chord member swung forward against the pier masonry might well be buckled. On the left side a tendency in this direction is indeed observable in the eighth cord. But the ninth chord lies far from the pier, in place, as it were, and can hardly be conceived to have returned after striking the stonework; especially is this obvious as chord 10 lies not far out of place as compared with its original position relative to the ninth, being on the pier side of chord 9.

The fact that no explanation of how the shape of this member could have been produced as a result of the fall seems available, leaves as the only remaining theory of the distortion a buckling of the member under great compressive stress. If the member, while in place in the bridge, buckled under its load, springing out laterally, it would allow the

panel-points at its ends to come together. This would drop the cantilever arm, since the anchor arm would move forward, following up the giving of the chord. The compressive force acting on A9L would thus continue to act, tending to crush the halves of the buckled member together, or break it at the middle, or, if the latticing gave way in the middle part so as to decrease the rigidity here, the member might be curled back upon itself in substantially the shape actually assumed.

THE DEFECTIVE CHORD.

We believe that the most thorough study of all that relates to the present and past state of chord A9L must be among the first things to engage the attention of those charged with the investigation of the disaster.

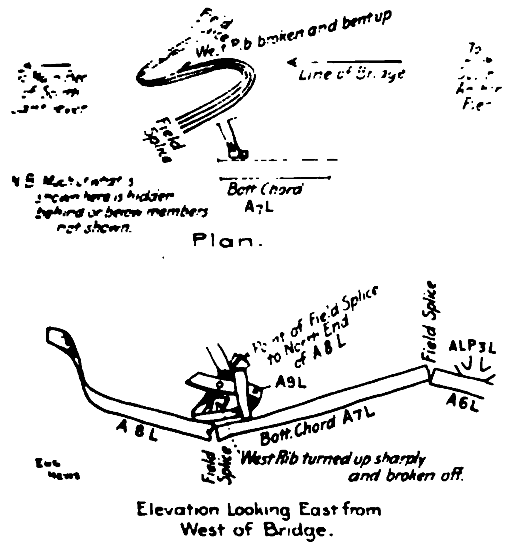

FIG. 5.—DIAGRAM SKETCHES OF THE LOCATION AND CONDITION OF BOTTOM CHORD A 9 L IN THE WRECKAGE.

This is the only chord section in the anchor arm that is buckled bodily. Many chord sections are broken, twisted, bent, and thrown far out of position relative to other parts of the wreckage, but only this one is buckled.

Prior Deflection Noted.—A very considerable support is given to the theory, however, by another circumstance, namely, that as early as three days before the collapse, the member in question was actually observed to be out of line. This observation was made on Monday, Aug. 26. A visible bend in chord A9L was seen on that afternoon, an inward bend. The following day it was measured, with the showing that all four ribs were deflected, at both top and bottom flanges, the amount of the deflection being from about 1½ to about 2 ins. for the several ribs. Fig. 6, a diagrammatic elevation and plan of A9L, to scale, but with the deflection exaggerated (dotted lines), pictures the conditions. At the same time there were indications that the latticing of the chord was stressed differently from its normal state. A rivet in one of the cross struts of the latticing that had been tight before was found loose, and the lattice diagonals "sounded high," as one man put it.

The deflection was not known to increase during the following three days, so far as our information goes. There can be no doubt, however, that its continuance in the deflected condition was a menace to the bridge. The matter was reported to the Consulting Engineer by his inspector, Mr. McLure, who went to New York for the purpose, reporting there

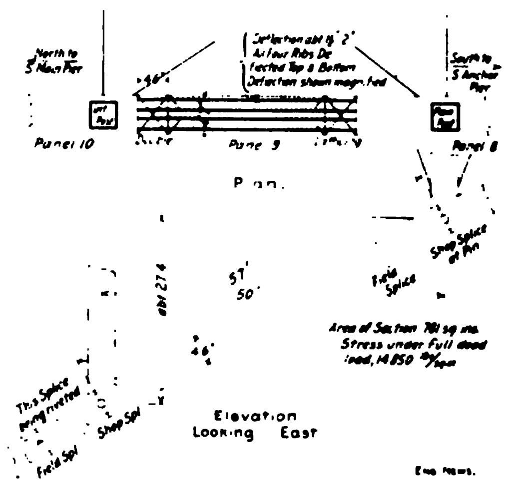

FIG. 6.—PLAN AND ELEVATION OF BOTTOM-CHORD SECTION A 9 L, SECOND FROM MAIN PIER IN WEST ANCHOR-ARM TRUSS.

The drawing is diagrammatic, but is correct as to scale. The lateral deflection of the ribs at their middle is, however, shown to about twice or three times its actual size as measured on Aug. 27.

Thursday morning, Aug. 29. At the same time the Superintendent of Construction, Mr. A. B. Milliken, went to the head office of the Phoenix Bridge Co. at Phoenixville, Pa. Mr. Cooper, when he heard of the observed deflection, sent a telegram which has given rise to numerous newspaper articles in the last few days. This was addressed to Phoenixville and not to Quebec, and read:

"Add no more load to bridge till after due consideration of facts."

The same afternoon the bridge collapsed. This coincidence in time is not, of course, proof of a casual connection between the deflection of chord A9L and the fall of the bridge, but the facts in themselves seem to

establish a fairly substantial chain of plausibility. The thing to note is that a strut of any kind that is bent out of line is not in the best of shape to resist high compressive stresses. Increase of load, or small influences of purely fortuitous nature, may increase its deflection, and under certain conditions, as when the stress in the outer fibers reaches the elastic limit, a buckling failure by continued deflection is a necessary consequence. These circumstances offer some explanation of why this chord is found in the wreckage in badly buckled condition, whereas the other chord-sections exhibit no buckling.

What may have been the origin of the deflection noticed in this chord on Aug. 26, is not directly indicated; nor is there anything to tell why this deflection should have led to failure after remaining apparently unchanged for three days.

Earlier Mishaps of the Chord A 9 L.—It appears that the history of this chord-section was not as uneventful as that of most of the other pieces of the steel work, and this history offers some support for the view that the section was slightly inferior to the others when it was set in place in the bridge. The chord A9L, it seems, had a short kink in one of the inner ribs before it left the shop, caused by some little awkwardness in handling the member. This kink, perhaps ½-in. deep and a foot or two long, was considered unsightly, but not harmful.

Somewhat more important is still another mishap, experienced in the storage yard a half mile south of the bridge site. While the chord section was being hoisted here, one of the hooks which held it broke, and the member fell flat on the ground on its top face. The field-splice plates at the end destined to adjoin chord A10L were bent or broken by striking a projection, and in turn they damaged the coverplate and the flange angles at the end. The damage was repaired, we understand, in workmanlike manner, the plates and angles being cut back and new end pieces spliced in. After these repairs the member was believed by all concerned to be quite up to standard, and in particular it was straight, we are told.

We confess our inability to conclude from the story of these mishaps, assuming their nature to have been as stated and the repairs conscientiously made, any great suggestion of alarm for this member as against a duplicate normal chord-section. It is only in connection with the subsequent events that the mishaps become prominent; the member in question actually deflected, it was completely destroyed by buckling when the bridge collapsed, and it is at the present moment perhaps the most suspicious point in the entire wreckage as regards causation of the fall. In view of this, the prior history of the member offers to the mind some degree of basis for speculation on the question why this particular strut should have failed, while the others in similar service remained apparently sound, and why it should have failed at so low a stress.

AS TO KNOWLEDGE CONCERNING THE STRENGTH OF HUGE COLUMNS.

We have already alluded above to the lack of absolute knowledge as to the strength of steel columns of enormous size, such as were of necessity used here. These compression members were designed for a unit stress under full dead, live and wind loads of 24,000 lbs. per sq. in., about two-thirds of the elastic limit of the metal. They were carrying at the time of failure not more than two-thirds of this amount. Were these compression members able to safely carry this stress? Were the plates and angles of which they were built up so thoroughly braced and connected together as to make the whole member act as a unit? Their design was made and approved by the ablest engineers in the profession. No one has dreamed of doubting their strength; but now, with the testimony of that gigantic collapse, every engineer must long to know, by absolute trial, what such huge columns can safely bear.

For, it is not proper to say that the history of several slight injuries to the buckled chord member relieves the weight of doubt in this matter by furnishing the explanation of abnormality. It cannot be said that a member is abnormal which is straight and sound enough to be per se acceptable under careful inspection. Is it at all certain that the undiscoverable variations of manufacture may not produce, in regular process, undisturbed by mishap, a column identical with this one? If inspection can not differentiate it, what surety have we on this point?

No, the doubt lies farther back. We step up from the ordinary columns of ordinary construction, tried out in multiplied practice, to enormous [illegible] thick-braced pillars of steel, and [illegible] the same [illegible]. Have we [illegible] warranty? [illegible] structures [illegible] the material [illegible] we do not [illegible] composite [illegible].

It is [illegible] Quebec

Bridge failure becomes of importance to the whole engineering profession. Until the cause is absolutely determined—if indeed it can ever be—or until the profession has actual results of tests of huge columns at its command, a cloud of doubt rests upon us as to the margin of safety in every great bridge structure; at any rate when the unit stresses are forced up to the point deemed safe by the designers of this bridge.

GOOD MATERIAL AND WORKMANSHIP.

Long and careful inspection of the wreck shows that the material was of excellent quality; that the workmanship was remarkably good. Bending, crushing, buckling, twisting, shearing and tearing are exemplified in the wildest variety of forms, and everywhere the most satisfying pliability and ductility are apparent. To cite a single instance: Where the anchorage legs were pulled over, their riverward lower corners were crushed in over the edge of the pier, as the views well show; these crushed parts of the plates are folded into tight accordeon pleating of much regularity, but we observed no cracks. This, be it observed, with steel which runs rather over 60,000 lbs., we believe, than under.

FIG. 7.—ANOTHER VIEW LOOKING SOUTHWEST TOWARD THE ANCHOR PIER.

Note approach span, overturned anchor towers, first section of lower chord of right truss, first main diagonal with middle portion of first intermediate post attached, section of floor with end floor-beam and stringers, buckled sections of last two panels of upper chord struts (wind truss only), and one post of main portal over anchor pier.

Some instances of square, sudden breaks in built members give a first impression of hard or brittle metal. This is an erroneous impression. For in almost every such case the same member exhibits, quite near the sharp break, other injuries—shear or tear of folding distortions—that demonstrate a fine degree of workability. In a particular case which struck our notice, a chord section on the left side, there is a sharp, almost conchoidal, break through all four ribs of the chord. But while one broken segment remained thus, the other was folded almost double on the longitudinal center line of the rib, the fold being transverse to the sharp fracture; and there is no cracking at the apex of this fold, even close at the broken edge.

The character of the rivets seems equally satisfactory. Large quantities of rivets failed, most of them by shearing, but some few in tension. In the sheared rivets, where indeed a tension may have been coexistent (tending

FIG. 8.—ANOTHER VIEW TOWARD MAIN PIER.

Break of main tower post across pier shows more clearly, and the lower tide shows more of the tower cap than Fig. 7. Post 4 of right truss, crushed down, appears in foreground. Sections of the top-chord eyebars and tension diagonals are in view.

to split the head off), the fractured face always shows a well-marked crescent of pure shearing or cutting action, whose widest part has a breadth of perhaps one-fifth the rivet diameter; the rest of the face being silky or finely granular—the sudden failure after the cutting shear had progressed far enough. Rivets failed in tension in very much fewer instances. But wherever they did it could be seen that quite a number of them had drawn down or necked quite visibly. In one case, a floorbeam was forced down off its connection with the post, a face connection; the upper part of this connection had failed in tension, part by tearing out the post, part by tearing the rivets. The latter were all necked down, and one of them in particular showed as complete necking and as pretty a cup fracture as we have ever seen. And this was a field connection—the rivets were field rivets! In other cases, a riveted connection which failed in tension showed simultaneous failure of rivets and plate, the holes in the plate being bulged through and greatly stretched, and

FIG. 9.—VIEW OF LEFT ANCHOR TRUSS, LOOKING NORTHEASTERLY TOWARD MAIN PIER.

A bottom-chord section broken and vertically displaced at the pin (shop splice) and broken at the field splice. Broken and buckled diagonal substrut; broken posts; top chord.

the rivet head being compressed and molded to such a size that it drew through the hole. An entire row of rivets failed in this way.

The workmanship found as good testimony in the wreck as did the material. This, however, is so essentially involved in a structure of this magnitude, if only for facility of erection, that it need not be remarked on in detail.

The doubt all centers around the design of those enormous long columns of which the lower chord and the vertical posts were made up. Did one of them fail under a load only one-half the elastic limit of the material in it? That is the question which must, for the present at least, be left unanswered.

RE-ERECTION.

The question of the re-erection of the bridge has not been fully decided, but on account of its immense economic advantage to the city and province of Quebec it is thought that the work will be carried on to a successful finish. Although the structure is primarily for railway purposes, the necessity for a better entrance into Quebec led the Dominion provincial and city governments each to contribute large sums of money toward the erection of the bridge. Throughout the work, then, the government has been largely interested in the successful prosecution of the project, and one of the first official acts after the collapse was the appointment of Messrs. Henry Holgate and J. G. G. Kerry, of Montreal, and Prof. J. Galbraith, of Toronto, to investigate the accident and make an official report thereon. This commission is now at work. The bridge is the enterprise of the Quebec Bridge Co., of which Mr. E. A. Hoare, of Quebec, is Chief Engineer, and Mr. Theodore Cooper, of New York City, Consulting Engineer. The substructure was built by M. P. Davis, of Ottawa. The design and erection of the steel superstructure was let to the Phoenix Bridge Co., of Phoenixville, Pa. Mr. John Sterling Deans is Chief Engineer of the latter company, and P. L. Szlapka the engineer to whom the design of the steel work is due.

We are informed that Mr. Leon S. Moisseiff, Engineer, Department of Bridges, New York City, has been appointed by the Dominion Government for the purpose of making a thorough investigation and report on the fallen structure.

FIG. 10.—A NEARER VIEW AT THE POINT WHERE BOTTOM-CHORD SECTION A 9 L LIES.

This chord section lies behind the two buckled posts in the middle foreground, but cannot be seen.

THE QUEBEC BRIDGE DISASTER

By ALBERT WELLS BUEL *

[The preceding article was submitted to Mr. Albert W. Buel, a prominent specialist in bridge design and construction, who, at our request, has favored Technical Literature with the following comments.—Ed. T. L.]

The editorial comments on the collapse of the south cantilever of the Quebec Bridge have reflected on the reliability, skill and competency of the engineering profession as a whole. This has not been confined to either the daily or the technical press, but has been common to both, and has been the general tone of all. This deduction against the profession as a whole is not justified by the evidence already brought out, and judgment should be withheld until the entire case is presented.

In the meantime, suggestions that may assist in reaching correct conclusions are in order, and, as far as they tend to relieve the profession from suspicion, are not only due to it, but will be beneficial to the general public.

While it would be premature at this time to give an opinion as to the cause of this failure, enough has already been published to justify the suggestion of specific points that call for investigation and need explanation, if, indeed, a very strong clue to the immediate cause has not been disclosed.

Interest centers on the lower chord member of the anchor arm, A9L. The "short kink in one of the inner ribs," received before it left the shop, and the rumor that it had been involved in a railroad wreck may be passed over at this time, although the effect of the kink, as well as any injury received in transit, will, no doubt, be given due attention in the course of a thorough investigation.

The nature of the injury received in the storage yard near the bridge site, and the method used for repairing it, call for the most minute investigation. What has been already published on this point is not satisfactory for the purpose of determining the probable primal cause of the disaster. Only an exhaustive report on this feature by experts in design and fabrication of bridges—not merely experts in mathematics and theoretical mechanics—can justify the conclusion that "after these repairs the member was believed by all concerned to be quite up to standard."

The lower chord members have been described as being 4 ft. 6 ins. deep by 5 ft. 7½ ins. wide, made of four (4) built channels, each having a 54-in. reinforced web and 8 × 3½-in. or 8 × 6-in. flange angles 1 in. thick, latticed top and bottom with single transverse angles dividing the space into square panels, each X-braced by single diagonal angles, one of which has its vertical flange cut to clear the other, which is made continuous.

We are told that the plates and angles were cut back and new end pieces spliced in. But we are not yet informed what relation these new end pieces had to the field splice, nor what precautions were taken to insure a TRUE bearing, if the latter was involved in the repairs. The difficulty of insuring the maintenance of true bearings (either pin or abutting) when changing or repairing built members with several webs, cannot be exaggerated, as any experienced bridge-shop man will testify.

The statement that it cannot be said that a member is abnormal which is straight and sound enough to be per se acceptable under careful inspection, is not satisfactory. It is possible that a variation in the bearing of one of these webs, almost too small to be detected in the field, would produce a moment, due to eccentricity of bearing, sufficient to account for the failure. In the shops bearings are bored or faced in machines, by methods evolved by forty years of experience, that practically insure them to be mechanically true and square. This is in answer to the editorial questions, "Is it at all certain that the undiscoverable variations of manufacture may not produce in regular process, undisturbed by mishap, a column identical with

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this one?" and, "If inspection cannot differentiate it, what surety have we on this point?" Moreover, inspection of finished product is infinitely inferior to continuous inspection during fabrication, and a very limited experience in inspection will prove the disadvantage of the former. For this reason the injury and repairs made near the bridge site need full explanation, either to establish the primal cause or justify the final acceptance of the member A9L.

No evidence has been published to show that a bearing of A9L was either defective or mechanically perfect, after the member fell in the storage yard, and had been repaired in the field, but it is a point worthy of the most careful investigation in seeking for the primal cause of the disaster.

Scarcely less important is the question: What was the effect on the angle lattice bars and their riveted connections, when the member fell flat on the ground on its top face? This may be difficult or impossible of determination, as such injuries are not always indicated by an external sign. The importance of this question will be brought out by what follows.

The preceding paragraphs refer more particularly to the investigation of the *primal cause*, which may never be disclosed. The immediate cause does not seem to be so completely obscured and the main purpose of this review is to point out a clue that should be followed to its end with minute precision.

"Engineering News," in its remarkably prompt and satisfactory report, says: "As early as three days before the collapse, the member in question was actually observed to be out of line. This observation was made on Monday, Aug. 26. A visible bend in chord A9L was seen on that afternoon, an inward bend. The following day it was measured, with the showing that all four ribs were deflected, at both top and bottom flanges, the amount of the deflection being from about 1½ to about 2 ins. for the several ribs."

In the report of testimony taken before the Coroner's Jury, Mr. Hoare, chief engineer of the Quebec Bridge Company, stated that Tuesday, Aug. 27, Mr. McLure, assistant engineer, reported to him verbally and to Theodore Cooper, the New York consulting engineer, in writing or by telegram, that on the ninth lower chord at the west truss a slight curvature inward was noticed. They did not consider it a serious thing.

This is a most surprising statement. The following questions naturally suggest themselves to the engineering expert in the design, fabrication and erection of steel structures: Were any computations made at the bridge site, on August 26 or 27, to determine the effect of 1½ ins. eccentricity of stress on the section of A9L? And, if so, what were the conclusions, or how was the conclusion that this deflection of 1½ ins. to 2 ins. was "not considered a serious thing" justified?

The maximum lower chord stress and section have been given as 16,000,000 lbs. and 842 sq. ins. A9L may not have been maximum, but can hardly have been greatly less than the maximum. "Engineering News" gives the probable stress in this member, at the time of the accident, at 17,000 to 18,000 lbs. per sq. in.

The full and exact data not being available, it is fair to assume for a preliminary investigation, not purporting to give true values, but only to indicate direction toward a "clue" and the approximate relative effect of a possible, if not probable, immediate cause, that A9L had about 800 sq. ins. sectional area subjected to 17,000 lbs. per sq. in. axial compression (the minimum given by "Engineering News"). This gives a total of 13,600,000 lbs. axial compression, or about 85% of the stated maximum for lower chord members.

Using the minimum deflection in A9L on August 27th of 1½ ins., the moment, on the assumptions here used, would be 20,400,000 in.-lbs.

Without the complete details of the member, the moment of resistance of the four built channels, about an axis parallel with the webs, cannot be computed; but a rough estimate made from the published description is sufficient to show that, under a deflection of 1½ ins., the lateral resistance of the four ribs would not be far from 10% of that required by the moment of over twenty million inch-pounds.

About 90% of this transverse bending moment would, therefore, seem to be what the lattice bars would have to resist. Were these angle lattice bars single or double riveted to the outside ribs? If single riveted, is it not true that the stress would have been high enough to fully account for the failure? If double riveted, and of sufficient strength, is it certain that when A9L fell flat on the ground on its top face none of the lattice bars or their connecting rivets were injured sufficiently to impair their value, and what method was adopted to ascertain such fact?

The load that caused such a flexure would certainly not require a very great increment to cause failure, and, if the figures and deductions given above represent even approximately the condition on August 27th, why was the work not stopped and the heavy traveler moved back to the pier on that date?

COMMENT OF THE ENGINEERING PRESS

"That the structure fell is, however, one of those grave facts which the engineer must face in all its stern reality. It seems almost hopeless to attempt to seek the cause of the accident in the twisted wreckage or to discover in the statements of those present at the time of the failure any clue to the reason for the catastrophe. Yet until that reason is definitely found engineering will be looked upon by the public with suspicion as daring too much for its resources and as too willing to run risks. Engineers themselves know full well that probably no structure ever received more careful attention in design, manufacture and erection than the Quebec bridge and they will be unwilling to attribute its collapse to defective proportions, inferior materials or faulty erection until definite proof is established to the contrary. Full details of the design and the method of erection have been published in a long series of articles in this journal, and elsewhere in this issue is a statement of all the facts that have been brought to light concerning the accident and the local conditions at the time it occurred. An examination into the accident is now being made by the Canadian authorities and it is to be hoped that this will be so thorough and complete that the cause of the collapse will be definitely revealed. Until it is known, the hazard of bridge-building on such a great scale will be something to consider with apprehension."—"The Engineering Record."

"One line of reflection suggests itself. Many of the members, and particularly of the compression members, in the bridge, were of quite an unprecedented size. In the present state of our knowledge there must be some doubt as to whether the experience gained from ordinary members in ordinary structures is fully applicable to those of much larger dimensions. In examining the wreck, the writer was struck with the lightness of the lattice angles on some of the huge chords and posts. Absolutely these bars were large, but relatively they seemed almost insignificant. Could any engineer undertake to say, with absolute certainty, that they were sufficient? Perhaps in this, or in some similar respect, the designers may have gone beyond the present bounds of engineering knowledge. Whatever the cause of the failure, a close study of the results cannot fail to be instructive and profitable to any bridge engineer."—H. M. Mackay, associate professor of civil engineering, McGill University, Montreal, in a specially prepared report of "The Iron Age."

NOTES ON SUPERHEATED STEAM*

By THOMAS SUGDEN

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*From [illegible]

unable to get more than about 10 to 15% of the total power from the coal we use transferred to machinery.

Properties of Saturated and Superheated Steam.—In order to clearly understand what is meant by the term "superheated steam," it will be necessary to refer briefly to the laws which govern steam generation:

(1) The temperature of ebullition, or boiling-point, increases with the pressure.

(2) For a given pressure, boiling always commences at the same temperature.

Steam in contact with the water from which it is generated is called "saturated steam," the temperature being the same as that of the water from which it is generated. The temperature will not vary so long as the pressure remains constant.

Dry saturated steam is steam which does not contain water, but some portion of which will condense into water immediately any loss of heat takes place. Such steam would be the ideal product of an ideal boiler, but is never attained under ordinary working conditions, as steam invariably carries more or less water, the degree usually varying from 2 to 3%; whilst, as the result of forcing or heavy firing, carrying the water-level too high, or the use of water which causes foaming, the percentage of water carried over with the steam is considerably increased, and sometimes amounts to 5%, whilst in extreme cases even 10% is exceeded.

From such consideration it is obvious that, in testing a boiler for evaporating efficiency, this factor must be taken into account, otherwise the results may be misleading. A boiler with a large disengaging surface is less likely to provide wet steam than one having a very limited area for the liberation of steam.

The properties of dry saturated steam were first carefully determined by Regnault; his experiments ranging from steam at 1 lb. pressure to 400 lbs. on the square inch. The tabulated results are given in most engineers' text books, and are expressed in terms of British thermal units—that is, the quantity of heat required to raise 1 lb. of water from 32° to 33° F.; or, generally speaking, a British thermal unit is the heat required to raise 1 lb. of water 1° F.

The table indicates that the higher the steam temperature the greater the increase of pressure; also that latent heat diminishes with the increase of sensible heat.

Production of Superheated Steam.—Superheated steam is produced by adding heat to saturated steam in a separate vessel called a "superheater." Superheat may also be obtained by the expansion of steam from a higher to a lower pressure without doing external work. The amount of superheat obtained in this way, however, is small, and narrows down the advantages which may be obtained from superheating.

Saturated and Superheated Steam Compared.—The chief differences between superheated and saturated steam may be briefly stated as follows: (1) Superheated steam is independent of pressure, and admits of variation in temperature, whilst the pressure remains constant. (2) The temperature of superheated steam may be reduced without condensation taking place. (3) Superheated steam practically follows the laws of a perfect gas. (4) Superheated steam is greater in volume than saturated steam of the same weight, but one pound of superheated steam contains more heat than one pound of saturated steam.

Specific Heat of Steam.—The specific heat of steam is measured in British thermal units, and as determined by Regnault and Hirn is usually taken as 0.48. Hirn adopted the following formula:

Specific heat at constant pressure $= 0.4304 + 0.0003779\ T$. ($T =$ temperature in degrees Fahrenheit).

It has long been known that 0.48 could only be taken as correct for steam at atmospheric pressure, and that for other pressures and temperatures the specific heat may vary from 0.48 to 0.75. Little, however, has been known as to specific heat at higher pressures and temperatures.

In Germany, where they are more advanced both as regards the theory and practical application of superheaters than we are in this country, the technical colleges have for some years been experimenting with superheaters, and recently experiments of a very elaborate and exhaustive character have been made at the Royal Technical University, Munich, to determine the actual value of the specific heat of superheated steam at various pressures and temperatures. These experiments were carried out with the utmost care by Messrs. Knoblauch and Jakob, and have only just been published. The results may be taken as quite reliable, and have contributed greatly to our knowledge on this subject.

SPECIFIC HEAT (c_p) AT

Absolute pressure of steam, lbs. per sq. in.	Saturation.	302° F	392° F.	482° F.	572° F.	662° F.
28.44	0.480	0.477	0.472	0.473	0.478	0.493
56.88	0.512	0.510	0.492	0.483	0.486	0.497
85.32	0.548	....	0.513	0.491	0.490	0.500
113.76	0.582	....	0.538	0.499	0.494	0.508

Steam Losses.—The loss of steam which is [illegible] useful mechanical work is attributable to two principal causes, viz.: [illegible] loss due to leakage, [illegible] loss due to condensation. Steam losses resulting from leaky valves, pistons, etc., are due to mechanical defects, and do not come within the scope of this paper; such losses, however, may be important factors in reducing the efficiency of steam engines.

Loss due to Cylinder Condensation.—The chief loss in engine efficiency is due to cylinder condensation.

[illegible]

superheat. This has been omitted from the results of [illegible] tests. It will be observed that in proportion to the increase of superheat the steam consumption is reduced.

Temperature of Steam, Deg. F.	Average Steam Consumption in lb. per [illegible] per hr.	Average Reduction in Steam Used, per cent.
Saturated	[illegible]	
Superheated		
[illegible]	[illegible]	[illegible]

[illegible]

higher value and increased power, capable of doing more work in the cylinder; it does, however, affect the boiler indirectly, as it enables the work to be done with 20 to 30% less steam in many cases, and, consequently, 20 to 30% less water. The effect of this is either to lighten the firing of the boiler or to increase its steaming capacity.

Transmission of Superheated Steam Through Pipes.—The flow of saturated steam through pipes is generally taken at the rate of 75 ft. per sec., whereas superheated steam will flow more easily at the rate of 100 ft. per sec.; while in Germany, where superheat is more generally adopted and better understood, steam is frequently used at a velocity of 150 ft. per sec. It is quite safe to allow for an increase of velocity of superheated steam as compared with saturated steam of 25 to 50%. On account of the high temperature of superheated steam it is advisable to efficiently cover all parts through which the steam passes, such as pipes, joints, etc., with non-conducting material. Superheated steam is transmitted with less loss than saturated steam, and may be carried a long distance without liquefying. If the interior of the pipes is kept dry, the flow of steam is not impeded, and, owing to the great mobility of the superheated steam, which travels at a much higher velocity, it can be transmitted through smaller pipes having less radiating surface; a dry metallic surface has been found to transmit heat with less loss than a wet surface. Saturated steam forms globules of water on the inside of the pipes and passages, which not only impede the flow of steam, but also more readily condense the steam and aggravate the bad effects of cylinder condensation.

The following table gives approximately the weight of steam per minute which will flow from various initial pressures, with one pound loss of pressure through straight smooth pipes, each having a length of 240 times its own diameter:

TABLE OF FLOW OF STEAM THROUGH PIPES.

Gage pressure in lbs per sq in.	Diameter of pipe in ins. (Length of each = 240 diameters.)					
	2	4	6	8	10	15
	Weight of steam per min. in lbs., with 1 lb loss of pressure.					
10	12.72	58.05	143.6	262.0	422.7	996
20	14.94	68.20	168.7	307.8	496.5	1,170
40	18.51	84.40	209.0	381.3	615.3	1,450
60	21.38	97.60	241.5	440.5	710.6	1,675
80	23.82	108.74	269.0	490.7	791.7	1,868
100	25.96	118.47	293.1	534.6	862.6	2,032
120	27.85	127.12	314.5	573.7	925.6	2,181
150	30.37	138.61	343.0	625.5	1,009.2	2,378

Construction of Superheaters.—There is now no difficulty in constructing superheaters to work in connection with modern high-pressure boilers, and of double the strength of the boiler. The disposition of the superheater and the relation between the available temperature of the flue gases and the heating surface of the superheater to give the desired degree of superheat are factors now easily determined by experts.

Superheaters should be made throughout of mild steel, of great tensile strength and ductility; they should be constructed so as to be easily accessible at all parts for cleaning, repairs, and inspection; provision should be made for cleaning the tubes whilst at work, and also for protecting the superheaters from harm during the time steam is first being raised by shunting the gases. When at work the whole of the gases should be compelled to pass among the superheater tubes in order to ensure the greatest efficiency. The effect of this is to greatly increase the degree of superheat, and the damper used for this purpose affords a means of controlling the degree of superheat. The steam inlet and outlet should be independent of the covers so as to avoid removing the pipes to obtain access to the superheater. A superheater constructed on these lines will last for years, and give good results.

Types of Superheaters.—Superheaters may be roughly divided into two classes, viz.: (1) Superheaters which are placed in the path of the boiler flame and heated with the boiler gases; (2) superheaters which are built up separately and independent of the boiler, and fired with a separate furnace.

It is advisable in all cases, where possible, to attach superheaters to the boilers, as such superheaters give better results, not only by way of economy, but they have the further advantage of supplying a fairly uniform degree of superheat.

If the boiler is off for cleaning, the superheater is off also; and if the boiler is doing little work, the superheater has less work to do; so that, whether the boiler is lightly or heavily fired, the superheater automatically corresponds with the conditions. Another advantage is that the superheater requires no attention, and is fired at the same time as the boiler and without an extra fireman.

With an independently-fired superheater a special furnace is necessary, also an attendant to look after it. A separately-fired superheater will give a very high degree of superheat, and, with a constant amount of steam flowing through, the degree of superheat can be fairly uniform, but, where the work is irregular, independently-fired superheaters are

not suitable, as there is always a liability of excessive temperature. The cost of obtaining superheat under such conditions, where coke or coal is used, is more than when the superheater is attached to the boiler. The amount of heat wasted from the superheater furnaces is very considerable, as the temperature of the gases leaving the superheater must be considerably in excess of the temperature of the steam entering the superheater; where possible, the gases should be turned into the main flue leading to the economizer so as to abstract any available heat and transmit same to the feed water.

The Effect of Superheating on the Economizer. Various tests which have been made show that there is little difference in the temperature of the feed water, which is probably due to the fact that when superheated steam is used a large percentage of saving in steam is effected, and consequently an equal saving in water, so that, although there is less heat available for the economizer, there is less water to be heated.

Provision for Superheated Steam.—All modern engines are now constructed so as to take a reasonable degree of superheat, say, 100° to 150°; metallic packings are now invariably used in high-class engines. The use of copper pipes and phosphor bronze should be avoided, as these metals deteriorate under the action of superheated steam; at the temperature of highly superheated steam, copper pipes will lose 30% of their strength. Steel pipes and cast-iron do not appear to be affected. It is now generally admitted that Corliss valves will work satisfactorily up to a temperature of 500° F. For a very high degree of superheat, drop valves are most suitable.

Lubrication. Although the difficulties in respect to lubrication have been set at rest by the introduction of hydrocarbon oils, yet wrong notions still exist as to a high quality of oil being necessary when superheated steam is used; as a matter of fact, an expensive oil is not essential unless a temperature of 600° or 700° is required. For temperatures up to 500° the ordinary commercial oils seem to answer the purpose. In many cases where superheaters have been installed, no difference has been made as to the character or quality of oil used.

Economy Resulting from Superheating.—Generally speaking, the economy resulting from superheating will show a saving in coal of not less than 10%. In many cases, where conditions are more favorable, this may be increased to more than 20%.

Concluding Remarks.—Ten years ago very few superheaters were at work in this country. It is difficult to ascertain the number now at work, but it is safe to say in this period they have increased by more than a hundredfold. The greatest progress, however, has been made within the last five years. The difficulties in connection with the construction and working of superheaters appear to have now been entirely overcome, and as superheaters are working which have been in use for some years without practically any anxiety by way of working expenses or repairs, it may be predicted that in the near future it will become the practice of manufacturers and steam users to adopt superheaters generally. The effect of a few failures in the early days has now disappeared, and, although there are still a few old-fashioned engineers who are opposed to superheat, their number is continually decreasing, and the time is at hand when the value of superheating will be fully and generally recognized.

CHEMICAL PROGRESS—THE WORK OF BERTHELOT, MENDELÉEFF, AND MOISSAN

FROM "ENGINEERING," LONDON

When Sir James Dewar completed a course of lectures on "The Old and the New Chemistry" a year ago at the Royal Institution, it was understood that the course would be supplemented in the following season, and when, early this year, the time was drawing near for deciding to which fields of the vast domain of modern chemistry Sir James should devote his lectures, we lost three great chemists within a few weeks of one another—Mendeléeff, Moissan, and Berthelot, and it seemed to Sir James to be appropriate to approach the subject of the progress of our age by a consideration of the work of these three giants, all of whom were members of the Royal Institution, and who represented three different types of mind—Berthelot was a colossus, to be compared to Liebig, without any modern parallel; Mendeléeff, the suggestive idealist; Moissan, the pure experimentalist.

Sir James opened his first discoures on Marcellin Berthelot, who was born in 1827, by biographical notes. When engaged in his first research, the study of the constitution of the fats—which are salts or esters of the fatty acids (stearic, palmistic, oleic acids, etc.) and of a trivalent alcohol, glycerin—Berthelot did not content himself with decomposing (saponifying) the fats by means of caustic alkali (steam or acids are technically used now to effect the same saponification). This decomposition yielded the alkali salt of the organic acid (a soap) and free glycerin. Berthelot also recombined fats from their constituents, prepared new fats, and further investigated the equilibrium of the reaction. He recognized that the reaction would proceed for a certain time in the desired direction, as decomposition, e. g., but the decomposition would not be complete. When certain proportions—depending upon the presence of water and other substances and on various conditions—had been reached, the action might reverse. Building up a body from its constituents was known as a synthetical process, and these researches led Berthelot to perfect syntheses; that is, the preparation of organic substances from elementary substances—charcoal, air, and hydrogen. Passing alcohol through red-hot tubes, he obtained complex substances; but the alcohol had itself first to be synthetized. The simplest organic acid—formic acid, or, rather, its alkali salt—he obtained from carbon monoxide (CO) and caustic potash; the acid itself should result from the combination of CO and water (H_2O), but these two would not combine.

The formic acid was a starting point. By heating barium formate, he generated marsh gas (CH_4), which further heating, or electric sparking, converted into C_2H_2, C_2H_4, C_2H_6, and higher hydrocarbons, finally, naphthalene ($C_{10}H_8$). The direct combination of carbon and hydrogen gave another starting-point. As these elements would only combine at high temperatures, which destroyed the resulting product—acetylene—he passed hydrogen through a bulb in which an electric arc was maintained between carbon electrodes, and withdrew the acetylene at once from the bulb. The demonstration of this very slow reaction was accomplished by cooling and condensing the little acetylene obtained in a U-tube; on warming this tube afterwards by the heat of the hand, the colorless hydrogen flame changed into the bright acetylene flame. As acetylene readily polymerized (its molecules unite to form higher compounds), and as it was also easily oxidized, further syntheses opened up. But Berthelot failed, even in his renewed attempts, in the last weeks of his life, to effect a direct combination between carbon and nitrogen in the absence of other elements. He did obtain prussic acid, however, from carbon, nitrogen, and hydrogen. This demonstration was accomplished with the aid of an electric arc in another bulb; and as this acid yielded with water ammonium formate, ammonia could also be introduced into the other synthetically prepared bodies.

While engaged in these remarkable re-

searches Berthelot also placed thermochemistry on a sure basis, working at first unaware of the simultaneous investigations of Julius Thomsen of Copenhagen, and from thousands of observations of the heats of combination of all kinds of bodies, Berthelot arrived at the conclusion that when two or more bodies react, those bodies will result which, by their formation, produce the maximum amount of energy. Sir James did not explain that this principle du travail maximum cannot be accepted strictly, but showed how the Berthelot calorimetric bomb is used. The bomb is a strong-walled vessel of steel, screwed up, in which substances or mixtures are burned or exploded by chemical or electrical means, after immersing the bomb in a calorimeter. In the demonstration of the bomb the combustion of an organic substance with oxygen under a pressure of [illegible] atmospheres, the temperature of the water rose slowly at first, rapidly afterwards. Sir James also demonstrated how the velocity of an explosive wave was measured by Berthelot. The two ends of a coiled tube were led towards [illegible]; the gas mixture was fired at the one end [illegible] and immediately afterwards the [illegible] appeared at the other end. The time interval could be measured by a chronograph. The coil used was immersed in [illegible] reaction. [illegible] of Berthelot. Sir James [illegible] to the tables, which contain the values of thermochemical data, [illegible] pressures, gas volumes, [illegible] explosives. [illegible] Berthelot was engaged [illegible] of thermochemistry [illegible] led blood [illegible] carbon dioxide [illegible] ent [illegible] times. [illegible] James [illegible] Berthelot [illegible] than [illegible] Berthelot [illegible] was French [illegible] come [illegible] bassador [illegible]

Dmitri [illegible] Dewar [illegible] who had [illegible] ing [illegible] sentially [illegible] the seventeenth [illegible] dealt [illegible] tions [illegible] experiments. Mendeléeff [illegible] crystallography and isomorphism, and then the relations between the pressure p and the volume v of liquids. He recognized that every liquid has an absolute boiling point (the critical temperature of Andrews), above which no liquid can exist as such, and he gave the formula [illegible] = [illegible] — [illegible]. This formula was less perfect than the one proposed by an Edinburgh bookseller, Waterston, at the same time, [illegible] = 1 — [illegible] log [illegible] —, where T is the critical temperature. But the papers which Waterston sent to the Royal Society were not heeded until Lord Rayleigh had them published later. Sir James showed how the liquid carbon dioxide half filling a glass tube expanded rapidly and was turned into a seething mass when warm water was poured over the tube, and how the meniscus of the liquid reappeared when cold water was afterwards poured over the tube. If the temperature had been uniform, the audience should have seen nothing, neither surface nor gas bubbles, at the critical temperature, at which the latent heat becomes zero and the volume of the liquid a maximum. The expansion of the liquid near the critical point was very rapid, and the ratio of the maximum volume of a liquid (at this temperature) to its minimum volume (at its greatest density) was for all liquids about [illegible]. In other words no liquid could, so far as we know, increase its volume by more than three times.

Mendeléeff, Sir James proceeded, then turned to gases. [illegible] could not be [illegible] meant that [illegible] any volume [illegible] there must [illegible] gas and similarly [illegible] say, a gas will [illegible] to an in[illegible] part of the [illegible] proved by a [illegible] Ama[illegible] which, [illegible] finally [illegible] there was [illegible] with the [illegible] was a [illegible] But the [illegible] expansion [illegible] strate [illegible] not now [illegible] searches [illegible] mos[illegible] retro[illegible] and [illegible] read [illegible] natu-

ral oils, and expressed the opinion that while the American oil, which seemed to be confined in relatively small natural reservoirs that were soon exhausted, might be of animal origin, the Baku petroleum was probably the product of the decomposition of metallic carbides, of which we knew very little in those days.

Passing to the periodic law, with which Mendeléeff's name will remain pre-eminently coupled, Sir James explained that classifications of the elements had been based by Dumas and others on the striking analogies presented by oxygen, sulphur, selenium, and tellurium, and their compounds, and by other families of elements. Those analogies and gradation of properties were shown by tables of the physical and chemical constants of these elements, and we shall revert to the point again in our remarks on Moissan's work. Following unknowingly in the wake of Newlands, Mendeléeff—and Lothar Meyer similarly at the same time—arranged the elements in twelve series of groups of seven or more elements, according to increasing atomic weights. The task was far bolder, Sir James said, than it appeared today; for the constants of the elements, which he regarded as periodic functions of the atomic weights, were less perfectly known then. Yet three lacunae in the table were soon filled up, as predicted by Mendeléeff, by the discovery of three new elements (scandium, gallium, and germanium), and his corrections of several atomic weights which did not fit his table were proved to be justified. Mendeléeff, Sir James stated, was not easily disturbed in set views. The rare earths were accommodated in his table, and room was found for the new gases as well by placing helium, atomic weight 4; neon, 20; argon, 40; krypton, 82; and xenon, atomic weight 128, at the heads of the old groups. In one of his latest speculations Mendeléeff suggested a chemical conception of the ether as a legitimate extension of his periodic law. Two more elements remained to be discovered, one of atomic weight 0.4 (hydrogen = 1), the other lighter even than the corpuscles or electrons, a kind of neutral substance that would not be attracted by the sun.

The third lecture was devoted to Henri Moissan, who was born in 1852 at Paris. Briefly reviewing Moissan's life, Sir James gave Moissan the credit of having rejuvenated inorganic and mineral chemistry in our age of organic chemistry. A pupil of Frémy and Deville—both famous inorganic chemists by the way—Moissan first studied the evolution of oxygen and of carbon dioxide by plants in the dark, investigated the oxides of the iron metals, and then took up the isolation of fluorine, which so many distinguished experimenters had tried before him. The alchemists knew that sulphuric acid attacked fluorspar, and generated from it a gas which corroded glass; the electrician Ampère first pointed out the analogy between hydrochloric and hydrofluoric acids. Kemp made vessels of fluorspar for the acid, which is now kept in paraffined bottles. Sir James exhibited the apparatus in which Moissan electrolyzed perfectly dry hydrofluoric acid. It was a U-tube of copper (originally platinum was thought indispensable), with plugs of fluorspar for the platinum electrodes, and two outlets, the one for the hydrogen, the other for the fluorine. The fluorine gas passed through a coil which, like the U-tube, was immersed in solid carbon dioxide to condense the fluorine, and through two tubes filled with sodium fluoride to absorb traces of the gas. The gas had a faint greenish-yellow color, and attacked almost everything; finely-divided carbon burned in the gas, forming a compound analogous to carbon tetrachloride (CCl_4), a colorless liquid, which we could not prepare synthetically out of C and Cl, however. That fluorine formed a similar volatile compound with silicon was shown with the aid of some fluorine gas enclosed in glass pipettes, sent by Professor Lebeau—Moissan's former assistant in these and other researches. The perfectly dry gas did not attack glass.

Dwelling on the analogies between fluorine, chlorine, bromine, and iodine, which form the so well characterized group of the halogens, Sir James showed that chlorine gas could easily be condensed to a yellow solid, and bromine to a red solid; the gases were contained in large inverted bulbs, and some liquid air was poured into the cup-shaped hollow at the bottom of the bulbs. The melting points of the four elements were in deg. Cent.:—F. (— 215) ?, Cl — 102, Br. — 7, I + 114; the boiling points in the same order, — 187, — 33.6, + 58, + 184° C.; the specific gravities, 1.14, 1.56, 2.95, 3.38; and analogous gradations were found to hold for the atomic weights, 18.91, 35.74, 79.84, 125.89; the atomic volumes, the atomic refractions, etc. Again, a similar gradation was observed in the properties of the compounds, except that the boiling point of hydrofluoric acid (+ 19.4° C.) was too high, probably because this acid polymerized. A study of the physical and chemical constants of certain organic (ben-

series) compounds of fluorine had, however, misled chemists in ascribing to fluorine a higher volatility than to hydrogen; fluorine would be condensed at about −215° C., as mentioned already.

The enormous activity of fluorine was marked by the number of heat units liberated according to Berthelot when fluorine and hydrogen combined to hydrofluoric acid (H F), viz., 38,600, while the formation of H Cl only liberated 22,000 heat units. Now solids hardly reacted on one another under ordinary circumstances, and we had every reason to believe that at absolute zero temperature all reaction must cease. As, however, fluorine still attacked the hydrogen of organic compounds when they were kept in liquid air, Moissan had doubted that fluorine would really become inactive at the lowest procurable temperatures. The day after Moissan lectured at the Royal Institution in 1897, therefore, Sir James Dewar and Mr. Lennox tried whether fluorine could be solidified, and how it would behave then. The fluorine did freeze [illegible] when liquid hydrogen was dropped on the solid the whole apparatus was shattered to fragments. [illegible] was the most active body.

With graphite, however, Sir James continued, fluorine only combined when the graphite was red-hot, with diamonds not at all. But graphite, and not diamond, was the most stable modification of carbon at high temperatures; and as minute diamonds had been found associated with other carbon, in meteorites, Moissan started on his preparation of artificial diamonds by melting iron and carbon (carbonized sugar) in a crucible, and dropping the fused mass into water. The iron would expand on solidification, and the chilled outer crust would subject the still liquid solution of carbon in iron inside to an enormous pressure. Sir James mentioned Moissan's preparation of the hydrides of potassium (K H), caesium and rubidium—snowy crystals, representing alloys of the metal and hydrogen, which did not conduct the electric current any more than hydrogen did—and to the many products which Moissan prepared in the electric furnace. Of the carbides, those of lithium, calcium, strontium, and barium, yielded on decomposition with water, acetylene C_2H_2; aluminium carbide gave marsh gas CH_4; manganese carbide yielded CH_4 and hydrogen; the carbides of the rare earths, cerium, yttrium, thorium, yielded C_2H_2, CH_4, ethylene C_2H_4, and some liquid paraffins; whilst the carbides of chromium, molybdenum, titanium and zirconium were not decomposed by water, so far as it had yet been discovered.

THE DESIGN OF REINFORCED-CONCRETE COLUMNS

[illegible]

resistance to longitudinal splitting or bulging of the column.

(6) The rods cannot take diagonal shear without overstressing the concrete.

The assumption that they can take shear, in amounts of anywhere near the capacity of steel to carry shear, is simply untenable and absurd, in spite of recognition in building codes and regulations. If, for example, we assume a shear of 12,000 lbs. in a rod 1 in. sq., there must, of necessity, be a bending moment in the rod. Now the square rod, at 24,000 lbs. extreme fiber stress, would take a bending moment of 4,000 in.-lbs. The lever arm of the 12,000 would then have to be only 1-3 in. The force of 12,000 lbs. applied on the side of a square rod in a length of 1-3 in., or on several times this length, is beyond the power of concrete to withstand.

(7) A plane of cleavage, especially if it be a sloping one, such as a joint left where pouring of concrete ceases for a while, will leave a weak section and vitiate to a large extent the factor of safety.

Compression of a reinforced-concrete column with a steel column as a basis of design is misleading, because of the fact that steel is very strong in tension and, therefore, capable of resisting bending stresses. Cast-iron columns were formerly proportioned on the basis of 11,300 lbs. per sq. in. (reduced for length). Full-size tests made some years ago showed this unit to be too high and that a proper unit is about 7,600 lbs., reduced for length of column. The compressive strength of cast iron in short blocks is about 100,000 lbs. per sq. in., but on account of the low tensile strength, and consequent low shearing strength, the safe unit in columns has but a remote relation to the compressive strength in short test pieces. An exactly similar condition exists in columns of plain concrete or of concrete that is not reinforced, with a view of relieving it of all tensile strains and of excessive shearing strains.

Practical experience has proven the inability of concrete columns in which small rods are imbedded to carry heavy loads. The practical experience referred to is the failure of buildings that have recently occurred.

It follows, then, that rational design of reinforced-concrete columns demands not only longitudinal reinforcement to take flexure stresses, but circular reinforcement to take the bursting or bulging force due to diagonal shear. Columns so designed have proven under test to be the strongest of all known forms of reinforced-concrete columns.

A good and efficient column is made by reinforcing a round or an octagonal column with a coil made of a square rod and with 8 longitudinal square rods wired to the same, just inside of the coil. The purpose of the longitudinal rods is to take flexural stresses—that is, to relieve the concrete of longitudinal tensile stresses due to any side force or any tendency to bow at the middle of the height of the column. The steel thus used is rationally employed, as it takes tension that would otherwise come on the concrete. These steel rods should not be counted upon to take any of the direct load of the column, because of the fact that tests show that such rods alone in a concrete column offer little or no assistance to the concrete.

When a concrete column is under compression, its length is diminished and its diameter increased somewhat. The steel coils come into play by this tendency of the columns to increase in diameter and are, therefore, in tension.

If we assume a safe load of 550 lbs. per sq. in. and a lateral pressure 10-48 of this in intensity, we have a basis for the determination of the tension on a coil. Let the pitch of the coil be ⅛ of the diameter of the column, and let

D=diameter of column in inches;

d=diameter of square steel rod in the coil, in inches.

Equating the equivalent fluid pressure on the rod to its tension at 12,500 lbs. per sq. in., we have

$$550 \times \frac{10}{48} \times \frac{D}{2} \times \frac{D}{8} = 12{,}500d^2$$

Solving we find

$$d = \frac{D}{42}$$

If we make the diameter of the coil ⅞ of that of the column, and the diameter of the square rod of which the coil is made 1-40 of the diameter of the column, we shall have close to 12,500 lbs. per sq. in. on the steel.

For the 8 rods which run the length of the column we may assume the same lateral pressure and proportion the rods to take that pressure. Assuming that they would act to resist the outward pressure of the disintegrated concrete, at the ultimate strength of the column, we can make the rods of a diameter that they would take the stresses in bending, at a safe unit, due to a lateral pressure 10/48 of 550 or 115 lbs. per sq. in. The outward

force per inch in the length of rod is 115 × [illegible] D ÷ 5. The clear span is [illegible] of D less 1/40 of D = 1/10 of D. As the rods are fixed ended, the bending moment is 1/12 of W L, or

$$M = \frac{115 \times D}{5} \cdot \frac{D^2}{100} \cdot \frac{1}{12}$$

Equating this to

$$16\,000 s^3 \div 6$$

the resisting moment of a square rod whose side is s, we obtain

$$s = \frac{D}{[illegible]}$$

As this is close to 1/40 of the diameter of the column, we may use the same size of square rod as that used in the coil.

It is recommended, therefore, that reinforced-concrete columns be made round or octagonal and that the entire area of the circle or octagon be considered as taking the load; also that the reinforcement be made of a coil of square steel rod of a diameter one-fortieth that of the column; also that just inside of this coil eight rods of the same diameter be wired to the coil. At the end of a coil the rod should lap a half circle, as this would be about 33 diameters.

The unit of 550 lbs. per sq. in. would be used for lengths up to 10 diameters. Between 10 and 25 diameters the allowed unit pressure would be found by the following formula.

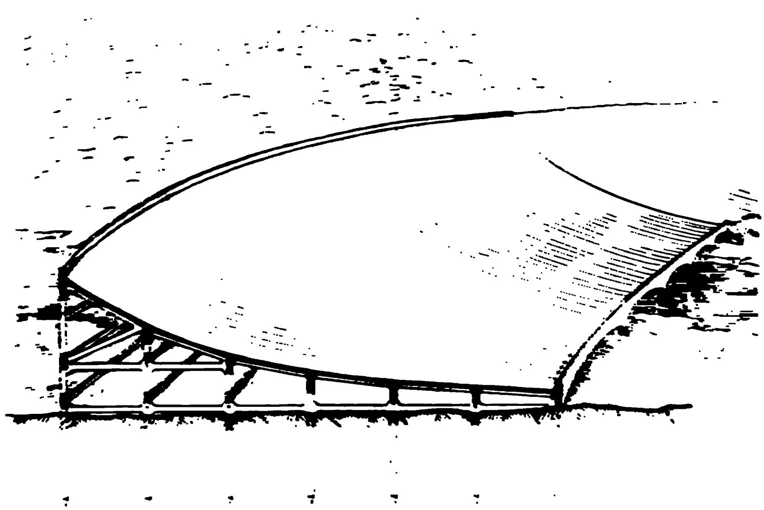
$$p = 670 - 12 \frac{L}{D}$$

where p = allowed pressure per sq. in.,
L = length in inches,
D = diameter in inches.

Columns more slender than 1/25 of their length should be avoided. The same reinforcement should be used in all columns of a given diameter, so that flexural and eccentric stresses will be taken care of in long columns.

WHERE THE 24-HOUR AUTOMOBILE RECORD WAS BROKEN

This race course, at Weybridge, England, on which Mr. Edge recently broke the record for speed on a 24-hour run, is 100 ft. wide and nearly 2¾ miles in length. Its shape is ovaloid, the two curves that join the straight runs being laid out at radii of [illegible] and 1,500 ft. respectively. Round the curves the track is banked up to a height of [illegible] ft., or 18 ins. more than was provided for in the plans, as an allowance for the settling of the earth. The straight roadways are finished with a concrete surface and the bowl ends are built on earth fills similarly finished. A portion of one end, however, spans a small creek, and at this point it was found necessary to employ reinforced-concrete beam and column



[illegible] BROOKLANDS RACE COURSE

construction. The [illegible] illustration shows the [illegible] and also gives an idea of the [illegible] required in order that speeds as high as [illegible] miles per hour can be safely attained. The gradient at the top of the bank is 1:1.6.

THE CUNARD TURBINE-DRIVEN QUADRUPLE-SCREW ATLANTIC LINER "LUSITANIA"

CONDENSED FROM "ENGINEERING," LONDON

e Lusitania is a most encouraging suc- It is not so much that her preliminary promise the realization of the contract ition that she shall make a double voy- on the Atlantic between Liverpool and York at an average speed of 24½ knots

THE CUNARD TURBINE-DRIVEN QUADRUPLE-SCREW ATLANTIC LINER "LUSITANIA," BUILT BY MESSRS. JOHN BROWN & CO., LTD., CLYDEBANK.

year of her entering the service— tifying in the highest degree—but carries a greater significance. Al- vessel certainly marks the prog- in marine construction, she must, regarded as a pioneer—as begin- era. This is because of the adop- cess on a huge scale of the steam- ship-propelling engine. Other true, are now run by turbine-driven screws; but when the system was decided upon for the Lusitania, the experience with this type of engine on a large scale was limited, and particularly so as regards durability. The confidence of the owners and builders of this ship, now justified by trials, gives promise that the future will see greater developments. In writing thus we do not disparage in the slightest degree the great work of the constructors. The Lusitania marks a step—great, but still only a step—beyond which Messrs. John Brown & Co., Limited, will probably be among the first to advance, because any review of the past, as well as of the achievements of the Lusitania, offers abundant encouragement for the future. We

[illegible]

[illegible]

[illegible] power into two [illegible] and independent systems follows the [illegible] pursued for so many years in the Navy [illegible] which is now so generally adopted in this respect [illegible] mercantile marine. [illegible] enabled the engine-rooms [illegible] well subdivided by watertight [illegible] and the advantages in general secured have been obtained without the sacrifice [illegible] point of any importance.

In the [illegible] devised to improve the [illegible] the dead wood was cut away. [illegible] the rudder, of the [illegible] type, is supported for about [illegible]. Immediately forward [illegible] are the two inner propellers, the shafting for these being entirely [illegible] the framing of which was [illegible] and strongly supported by [illegible]. The forward propellers are about [illegible] ahead of the inside screws, and here also the frames are carried by heavy [illegible]. Owing to the great beam of the ship, and the very fine run, the blades of the outside propellers do not project beyond the

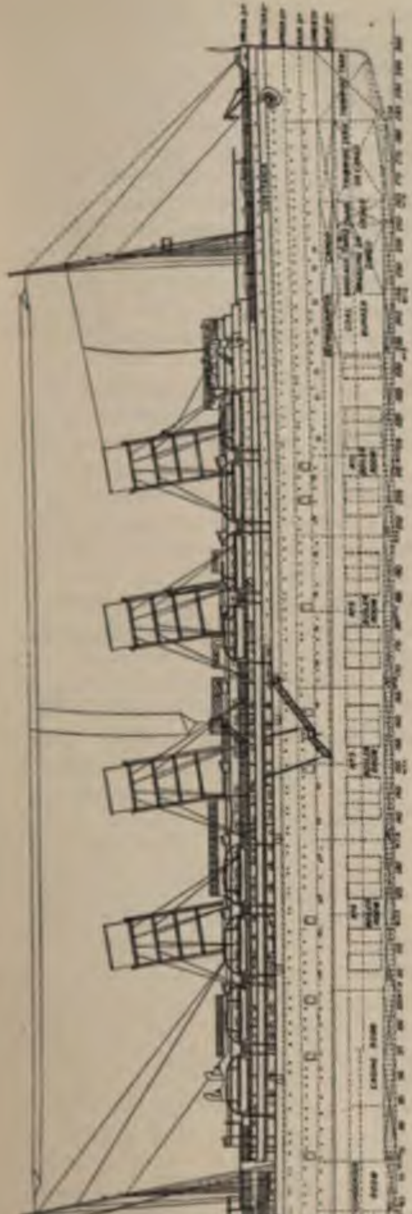


FIG. 2.—PROFILE OF THE TURBINE-DRIVEN QUADRUPLE-SCREW CUNARD LINER "LUSITANIA."

beam-line, while, at the same time, all the propellers work in free water, and provision has been made for a satisfactory clearance between the propellers and the skin of the ship.

It was decided in the Cunard liners, after very careful consideration, to attain the full speed, with the propellers making about 140 revolutions per minute, and the turbines were proportioned to suit this speed. The peripheral speed being practically more or less constant, owing to the velocity of steam, and only affected by the angle or curvature of the blades, it became necessary to adopt turbines of very large diameter. Thus the rotor-drum of the high-pressure turbines is 96 ins. in diameter, and that of the low-pressure turbine 140 ins., the blades ranging from 2¼ ins. to 22 ins. in length. The result is to permit the use of a propeller of a diameter and pitch which will certainly remove any question as to relative efficiency, under normal conditions, as to manoeuvring power and astern speed, and also as to the influence of head seas.

CONSTRUCTION OF THE SHIP.

Stresses.—The calculations of stresses were carried out in the usual way, on the assumption that the material of the hull, if built of mild steel, should not be subjected to a stress exceeding 10 tons per square inch, and on the basis that the vessel might experience the hogging and sagging stresses consequent on meeting with waves of her own length, and of a height from the trough to crest of one-twentieth of the length of the wave. The very careful series of calculations entered into showed that the maximum bending moment was slightly over 1,000,000 foot-tons, and that this occurred through hogging, owing to the vessel riding at the center of her length on the crest of a wave of maximum size with the ends in the troughs. This stress, of course, is greatest at minimum draught; that is to say, when the vessel is nearing her destination, and when coal in her bunkers has been greatly reduced. With the two ends supported on waves and the center sagging, the stress was only about 500,000 foot-tons. With a full cargo of coal, when the displacement will probably be 20% more than in her arrival condition, the hogging and sagging stresses are considerably less. These conditions are about normal, but the aim of the designer was to meet them so that the strain on the structure would be less even than is usually the case with well-built ships.

In the case of the Lusitania it was decided,

before construction was far advanced, to enter upon a series of very careful tests in order to determine whether and to what extent increased strength could be imparted to the upper structure by the adoption of high-tensile steel. The ordinary tensile and elongation tests carried out in the interests of the builders by Messrs. David Kirkaldy and Son, London, were supplemented by a great variety of experiments, and these showed that the average ultimate tensile strength of the material selected was [illegible] tons per square inch for normal high-tensile steel and [illegible] tons per square inch for annealed high-tensile steel, as compared with [illegible] tons per square inch for ordinary mild steel. The elongation tests were made with pieces which corresponded more to the length of plates on the section of the ship—namely [illegible] ins.—and it was found that the ratio of elastic to ultimate stress was [illegible] for the normal high-tensile steel and [illegible] for the annealed high-tensile steel, as compared with [illegible] for the mild steel. Thus the high-tensile steel which was used was [illegible] better in ultimate tensile strength than the mild steel, which itself was of a very satisfactory quality. The metal was subjected to [illegible] tests as well as to other severe punishments, including the explosion of heavy charges of dynamite against the plates, and in every instance the results were satisfactory. Generally speaking, the conclusion [illegible] from these experiments was that the [illegible] than the mild [illegible] great [illegible] justified [illegible] greater [illegible] thinness of [illegible] problem of [illegible] torpedo craft.

The [illegible] thicknesses [illegible] straps. [illegible] tions in the [illegible] this there is [illegible] are two [illegible] ers. In addition, however, [illegible] side of the center-line keelson [illegible] gitudinal girders.

Contrary to usual practice [illegible] these intermediate longitudinals [illegible] ing the structure are placed with their larger dimension vertically instead of horizontally. This was because of the comparative closeness of the frames, but as a consequence one may walk in greater comfort through the ballast-tanks. There was no attempt to make these intermediate continuous longitudinals water-tight. The water-tight divisions of the ballast-tanks between the double bottom are made by the center keelson and the two main longitudinals. This double-bottom construction extends for practically the whole length of the vessel, and extends for a considerable part of the length of the vessel up to the lower deck.

As regards the plating, the only departure from recent practice at Clydebank is the connection of the plates of the garboard strake to the flat keel-plates. Mention may also be made of the longitudinal connecting angles having no butt-straps. The frames and reverse bars up to the margin plate are joggled, to avoid the necessity for slip iron. Practically all the holes in the keel-plates were drilled in place, the plates being subsequently separated so as to remove the burrs from the surfaces, the edges of the holes were slightly reamed, and the whole reassembled for riveting. The double-bottom plates, as well as most of those used in the main structure of the ship, are at least [illegible] ft. in length. The connecting-bars of the center-line girder were [illegible] as it was found by experience necessary [illegible] garboards in place before [illegible] flat keel was proceeded with [illegible] great closing power [illegible] used.

[illegible] used for a considerable [illegible] as well as the sheer-[illegible] the hull amid-[illegible] doubled thickness [illegible] adopted. The [illegible] butts of the [illegible] outside and inside [illegible] side plates, the [illegible] rows of rivets, and [illegible] rows, the thickness [illegible] on account of [illegible] inside plates [illegible] quadruple-riveted.

[illegible] of high-tensile [illegible] parts, and [illegible] deck. Above [illegible] of high-tensile [illegible] transverse [illegible] connected con-[illegible] bunker

bulkheads, by the two bulkheads in the engine room, and by the partial bulkheads in the coal-bunkers. Referring to the stem and stern framings: The stem is of cast steel, and was constructed with rabbets to receive the shell-plating. The weight was 8.3 tons.

The heavy section of double bottom, and the bossing out of the framing for the propelling shafts, are of great interest. The spectacle eyes—monocles would be a more accurate term—for the outer shafts are of cast steel, and well incorporated with the framework of the hull 90 ft. before the after perpendicular. The spectacles for the two inner shafts, which are at 19 ft. 6 in. centers, are also of cast steel, and are riveted to the stern-post. This latter is a steel casting, of a special form, to support a balanced rudder and to take the steering-gear in duplicate. The weight of the stern-post is 59.4 tons, exclusive of the spectacle frames, which, together, weigh 60.2 tons.

The rudder, which weighs 56.4 tons, is composed of three steel castings, and the rudder-head is of forged steel; all the parts are connected by horizontal flanges, well rabbeted and heavily bolted. The rudder area is 420 square feet; there is one removable pintle.

PASSENGER ACCOMMODATION.

The following table shows the cabin accommodation for the various classes of passengers:

List of Rooms for Passengers.

First Class. (540 Passengers.)
36 one-berth rooms.
150 two-berth rooms.
72 three-berth rooms.
Total, 260 rooms.

Second Class. (460 Passengers.)
60 two-berth rooms.
85 four-berth rooms.
Total, 145 rooms.

Third Class. (1200 Passengers.)
40 two-berth rooms.
237 four-berth rooms.
21 six-berth rooms.
4 eight-berth rooms.
Total, 302 rooms.

The dining accommodation is given in the table following:

Accommodation of Dining-Saloons.

		Seats.
First Class.—	Upper saloon	150
	Lower saloon	350
	Children's saloon	40
	Total	540
Second Class.—	260 seats.	
Third Class.—	Main saloon	340
	Ladies' room	90
	Smoking-room	110
	Total	540

A feature in the arrangements for the comfort of passengers is the complete equipment of lifts for passengers, baggage service, etc. In all eleven lifts and hoists have been installed, all worked by electric current supplied by the ship's generating plant at a pressure of 110 to 120 volts.

Of these hoists, the two passenger lifts running within the stair-well are probably the most interesting in the ship. These travel through a height of 36 ft. 3 ins. between the main and boat-decks, opening on to the splendid vestibules or halls on each deck leading to the various public saloons or to the alleyways through the extensive ranges or cabins.

Ventilation.—The thermo-tank system has been adopted in connection with the ventilation of the ship. This system aims specially at insuring to all the living quarters of the ship a continuous supply of fresh air, which is not only warmed to the requisite degree, but is also humidified, so that none of the bad effects of over-drying can be felt. In cold weather the warmed air is discharged, through a regulated louvre, into each apartment, near the level of the ceiling; as it cools it gradually sinks to a lower level, carrying with it any carbonic-acid gas to the passageways, where means are provided for allowing it to pass outside. In warm weather, or when heating is not necessary, the reverse action takes place, as the louvres near the ceiling constitute the exhaust, with the result that the warm impure gases leave the top of the room, and fresh atmospheric air comes in at the floor-level.

The thermo-tank generally consists of an electric motor operating a fan which discharges air to the outside of a tube heater. The air then passes through the tubes, and comes in close contact with the heater surface, flowing thence to the main distributing-trunks. Two valves are used for controlling the passage of air; one for regulating the temperature, while the mushroom valve on the top is provided for the exhaust air. It will be noted that the air passes round the outside of the heater on its way to the tubes, so that the loss from radiation is very small, the outer casing of the thermo-tank being quite cool on all occasions. The heater is warmed by steam

[illegible]

[illegible] Howden system [illegible] the forced-draught fans being driven by electric motors.

Turbines.—The high-pressure turbine rotor-drums are [illegible] diameter; the astern drums [illegible] and the low-pressure drums [illegible]

[illegible] will naturally be inferred that the forgings [illegible] required [illegible] will [illegible] be of very large size. The [illegible] for the turbine-drums [illegible] and straight shafting were [illegible] Messrs. John Brown & [illegible] Sheffield. The turbine-drums were [illegible] forged, and the low-pressure [illegible] are the largest hollow forgings [illegible] up to the present time. The [illegible] drums, as delivered [illegible] as follows: Outside diameter [illegible] diameter, 11 [illegible] with metal [illegible] ins. [illegible] extremely large, [illegible] coupling-flanges [illegible] being as large [illegible] The in-[illegible] diameter, and [illegible] by over [illegible] thrust-shafts [illegible] of high-tensile [illegible]

[illegible] in which these [illegible] by Thomas [illegible] who have [illegible] castings [illegible] to practi-

cally every firm of turbine-builders in Great Britain. The wheel illustrated was for the low-pressure turbine, and each wheel weighed 11¾ tons. Owing to the great contraction that takes place in steel—double that of cast iron—the greatest possible care has to be exercised in the molding of such huge wheels to avoid possible failures, and only long foundry experience and skill can overcome the difficulties.

The turbine-blades vary from 2¼ ins. to 22 ins. long. In the longer blades the necessary radial and lateral stiffness is obtained by means of three rows of shrouding, in which expansion is allowed for.

The foregoing extracts have been taken from an exhaustive description of this modern ship, in "Engineering" (London) of Aug. 2. Sixty-six pages of that issue were devoted to the subject, embellished with over 180 line drawings and half-tone illustrations.

Official trials were made of the Lusitania July 28-31. In the first trial, a 48-hour run, a mean speed of 25.4 knots was made under the normal draft of 32 ft. 9 ins. on the Atlantic trip (displacement, 37,000 tons).

The Lusitania started on her first voyage to New York at about 6 P. M., on September 7, leaving her berth on the Mersey amid the cheers of the assembled thousands, whose enthusiasm and numbers were quite commensurate with the importance of the event.

She left Daunt's Rock at 12:10 p. m., on Sunday, Sept. 8, and arrived at Sandy Hook Lightship at 8:04 a. m., Sept. 13, having made her first voyage in 5 days and 54 minutes. This is 6 hours and 29 minutes better than the best previous record from Queenstown to New York, made by the "Lucania" in 1894. The daily runs were as follows:

	Nautical miles.
First day	561
Second day	575
Third day	570
Fourth day	593
Fifth day	483
Total	2,782

Average speed for trip in knots.........23.01

COMPARATIVE TABLE OF OCEAN LINERS.

Name.	Date.	Length, ft.	Displacement, tons.	I. HP. of engines.	Speed, knots.
Great Eastern	1858	680	27,000	7,650	14
Britannic	1874	455	8,500	5,500	15
Umbria	1885	500	10,500	14,300	18
Campania	1893	600	18,000	30,000	20
Kaiser Wilhelm der Grosse	1899	625	20,800	30,000	22
Deutschland	1900	662	23,000	36,000	23
Kaiser Wilhelm II.	1903	678	26,000	38,000	23½
Adriatic	1907	725	38,000	40,000	23
Lusitania	1907	785	45,000	68,000	*25½

*Trial speed.

PREVIOUS RECORDS.

Ship.	Course.	Distance, miles.	Time.	When made.	Best day's run.	Hourly average, knots.
Deutschland	N. Y.—Plymouth	2,982	5 days 7 hrs. 38 min.	Sept., 1900	549	23.51
Kaiser Wilhelm II	N. Y.—Plymouth	3,082	5 days 11 hrs. 58 min.	June, 1904	564	23.58
Kaiser Wilhelm der Grosse	N. Y.—Cherbourg	3,184	5 days 16 hrs	Jan., 1900	574	22.63
Lucania	N.Y.—Queenstown	2,800	5 days 7 hrs. 23 min.	Oct., 1894	562	22.01
La Provence	Havre—N. Y.	3,170	6 days 3 hrs. 24 min.	May, 1906	541	21.53

The New York-Plymouth record has been in dispute since the Kaiser Wilhelm II. made her fast trip in 1904 The Kaiser sailed the long course, and therefore the North German Lloyd officers claim the record. All distances recorded in nautical miles. [One knot = 1 nautical mile (6,080 ft.) per hour.]

FULTON'S BOAT, THE "CLERMONT"

It is difficult in this year of grace to realize, says "The Engineer" (London), "that it is only 100 years since navigation by steam [illegible] reached the position of a recognised commercial means of transport, nevertheless such is the case. Out of the crude but successful [illegible] of Fulton has come the [illegible]

[illegible]

considerable length in Technical Literature for August, and we now briefly supplement that presentation of the subject with a few of the dimensional details of Fulton's boat, together with illustrations which have been reproduced from originals appearing in the journal above quoted.

The "Clermont" was 133 ft. long, 18 ft. beam, 6 ft. depth of hold, 2 ft. 6 ins. draught, and 160 tons Customs measurement. The engine (see Fig. 1)—which had been completed in 1805 and had been shipped to the United States before Fulton left England, was of the Bolton & Watt type introduced by the makers not long before that date. It had a single [illegible] 4 ft. stroke, and [illegible] The connecting parts and [illegible] were planned and executed [illegible]

The paddle-wheels were 15 ft. diameter, [illegible] dipping 2 ft. into the [illegible] was of the [illegible] [illegible] The engine [illegible] and stern were [illegible] There [illegible] and [illegible] New York to [illegible] Livingston [illegible]

FIG. 2.—THE PADDLE-WHEEL STEAMBOAT "CLERMONT."

bany. The total voyage of 145 miles was made at the rate of nearly five miles per hour. Returning the day following to Clermont, Fulton proceeded to New York, having completed the return voyage at about the same speed. This was followed by a number of other trips, which were hardly successful financially. Before the season closed the paddle-wheels were boxed in and outside guards fitted; during the winter of 1807-8 the "Clermont" was lengthened to 166 ft., flush-decked from stem to stern, and fitted with cabins and berths—see Fig. 2. Before the end of the season of 1808 she proved too small for the number of passengers who were anxious to travel by her.

In the following table the principal data of the "Lusitania" and the "Clermont" are given, together with their respective ratios.

	Lusitania.	Clermont.	Ratio.
Length	785 ft.	133 ft.	6:1
Breadth	88 ft.	18 ft.	5:1
Depth	60.37 ft.	6 ft.	10:1
Tonnage	32,500 tons	160 tons	203:1
HP.	68,000	19	3,580:1
Speed in knots	25	4.4	5.7:1

THE ICE PROBLEM IN ENGINEERING WORK IN CANADA*

By HOWARD P. BARNES, D. Sc.

During the severe Canadian winter there is excellent opportunity for the physicist to study, on a grand scale, the operation of the natural laws governing the formation of ice in the many forms with which it is met in the large and often turbulent rivers. To the engineer the problem is more serious, for the development of the vast water-powers of the country must include means of combating the ice troubles which arise each winter. What presents itself during the summer months for consideration is small compared to what must be met during the winter months, when ice is forming rapidly, and ice-bridges, dams, and

*From a paper read before Section G of the British Association at Leicester, August 7, 1907.

shoves, may change the whole character of the levels and channels in a single night. Rivers are thus known to have been turned entirely out of their course into new channels during a winter of unusual severity, and in some instances the reversal of a rapid is of yearly occurrence. No one set of conditions may be said to hold from year to year, on account of the variation in the severity of the winters. Therefore, before an engineering scheme is carried out, a careful study is usually made of neighboring conditions, previous summer and winter levels, and deductions made from a consideration of native traditions over an extended region round about.

Nowhere can one witness a more wonderful sight of the delicate poising of the forces of Nature than in one of the Canadian rivers in winter. The steadiness of the temperature of the water throughout the ice season is a matter of great interest. It seldom varies more than a few thousandths of a degree from the freezing-point, even in the severest weather. This is true for rivers flowing too swiftly for surface-ice to form, as well as for the quieter streams protected by an ice covering.

In general, three kinds of ice are distinguished and present characteristics brought about by their method of production. Surface or sheet ice forms over the surface of [illegible] and is desirable or not according to the particular conditions. Spongy [illegible] as it is called in Canada, frazil-[illegible] surface agitation [illegible] [illegible] waters.

[illegible]

is found to follow more or less completely the contour of the bed of the river. In some parts of the St. Lawrence, thicknesses 80 ft. deep have been measured by a sounding-rod let down through the spongy accumulations through an opening in the surface ice.

Anchor ice grows in large quantities during the severe weather, not only by radiation, but by the general adhesive properties of the frazil-ice during the time in which the water is in a super-cooled condition. Open portions of the St. Lawrence are observed to rise, during cold weather, several feet, owing to the accumulation of ice on the bottom. This accumulation is not without benefit to power-users while it lasts, for it is probably the most effective agent in clearing the water from frazil-ice that is known. Shooting up in long needle crystals through the water, taking arborescent forms, it attaches and filters a great deal of the fine floating ice swept down by currents. It is a matter of comment amongst power-users that there is less fear from ice-troubles during prolonged cold weather than when the weather is intermittently warm and cold, a condition which keeps the bottom fairly clear of anchor ice.

A study of the temperature conditions in the water during the production of these forms of ice shows that this is accompanied by a small temperature depression in the water amounting to a few thousandths of a degree Centigrade. During the severe weather the water is thus thrown into a slightly supercooled state, during which time the ice crystals are growing rapidly by continued freezing and giving rise to the agglomerating stage, [illegible] together into lumps and [illegible] masses, and adhere to the racks or to [illegible] of the [illegible]-gates or turbines. [illegible] that it will interfere [illegible] the operation of the [illegible] temporary cessation [illegible] frequently be[illegible] off entirely the [illegible] It is only a [illegible] depression which brings [illegible] methods of arti[illegible] affected spots. [illegible] the situation. [illegible] agent in pre[illegible] absorption of [illegible] supercool[illegible] has been found [illegible] a system of [illegible] which can [illegible] machinery, in [illegible] coming super-

cooled. It is not found necessary to warm the entire volume of water passing through, which would be very costly and difficult; but by applying the heat in the racks or wheel-cases, or blowing steam about the affected parts, the ice is prevented from gaining a foothold. The ice is as effective as so much water in producing a head; hence the necessity of passing it through, and not allowing it to freeze to the metal surfaces of the machinery.

In places where the steam-injected system is installed, no trouble is experienced, even in the most severe weather; thus completely demonstrating the feasibility of coping with a situation which, for many years, has been regarded as involving inevitable interruption to the continuous operation of the plant.

The most effective prevention to the formation of both frazil and anchor ice is the protection afforded by a surface sheet. When a power-house is located at the foot of rapids, or at the head of a rapid with open water above, means are taken to construct a head-race of sufficient magnitude to serve as a settling basin for the ice drawn in. Much of the ice is deflected at the head of such a channel by the construction of booms or crib-work. Even in this case a large staff of men may have to be employed to cut channels through the ice of the head-race to allow of sufficient water for the turbines.

In cases where a channel to a power-house is fed from rapids, the growth of surface ice over the channel is often a disadvantage, and artificial means are employed to keep the channel open. The frazil-ice which passes under the booms is passed along as quickly as possible, and handled by artificial heat at the wheel-house.

THE PRESENT POSITION OF GAS AND PETROL ENGINES*

By DUGALD CLERK

The present position of the internal-combustion motor industry in Great Britain is one of sound commercial prosperity. At no previous time have the gas and oil engine builders had so many orders in hand, and never before have these motors been applied so successfully to so many different purposes. Smooth success, however, is not interesting from the point of view of the scientific investigator or inventor; and, accordingly, I propose to discuss the present position with regard to existing difficulties rather than existing successes.

Engines of small and moderate powers are built in large quantities; their difficulties have been thoroughly overcome and they have attained to an almost fixed type. The larger part of the British gas-engine industry is occupied with such motors, generally under 100 HP. per cylinder. The turnover in Britain at present of such engines is at the rate of some 300 engines per week. It is generally recognized that these engines are as reliable as the best steam-engines of similar dimensions and much more economical in fuel consumption. The smaller engines mostly use coal gas, and the larger producer gas, evolved by means of modern suction producers using anthracite for fuel.

Experience in the construction and design of the large gas-engine is accumulating. They are better understood in Britain than they were even three years ago. It is a remarkable fact, however, that engines which attained a reputation for success upon the Continent were not at first successful here. This is shown by the fact that the Koerting, Oechelhauser, and the Cockerill engines had all to be modified in their construction by the British engineers who undertook their manufacture here. This is also true of the Diesel oil-engine. Alterations have been made in England to fit it for the conditions of practice here. All these engines have been much improved in the last few years, and they are now, no doubt, better able to compete with the steam-

*Slightly condensed from a paper read before the British Association at Leicester

engine with regard to reliability and freedom from breakdown.

Large gas-engines of English design have also been built in greater numbers, principally by the Premier Company, Messrs. Crossley Bros., Limited, and the National Gas-Engine Company. English designers have also felt the desirability of keeping down cylinder dimensions as much as possible, and in this Continental designers have recently shown a strong tendency to follow them. This trend is due to a more general recognition of two facts: practical difficulties with large-diameter cylinders due to unequal expansions, resulting in cracking, and a better appreciation of the fact that increase in cylinder and other dimensions requires an increased expenditure in metal and workmanship in greater proportion than increase of power obtained. The large gas-engine really presents two distinct problems. The first is to build engines of large power which will continue to run effectively and economically for long periods without breaking down, and the second is to build such engines at costs sufficiently moderate to enable the engines to effectively compete with the large steam engines in the matter of first cost. British engineers recognized for some time that the first part of the problem has been solved to some extent on the Continent, but many of them have felt that this solution has involved weights of material and costs of construction which are almost prohibitive, considering the moderate powers obtained. In fact, English engineers consider the large gas-engine as it at present exists both too heavy and too costly for its power. Personally, I do not believe that sound and continued commercial success can be looked for with really large gas-engines until some better solution be found for their present constructive difficulties. Apart from the questions of the engines themselves there are other difficulties which prevent the equal competition of gas-engines with steam-engines for powers, say, greater than 400 HP. or 500 HP. Coal gas is too expensive a fuel for large engines. Producer gas, evolved by the suction producer from anthracite, air, and steam, effectively meets the wants of medium-sized engines up to 200 HP., but the cost of anthracite handicaps engines of larger size, and equal competition will not be possible until better bituminous fuel producers are designed than those which at present exist. The work on the Continent has not aided the solution of the bituminous fuel producer problem. Practically all the large Continental gas-engines are operated with blast-furnace gas. Some success has been attained in Britain as the result of strenuous and praiseworthy efforts by Dr. Mond, Messrs. Crossley, and others, but it cannot yet be said that an entirely satisfactory bituminous producer has appeared. In my view no bituminous fuel producer can be considered really satisfactory until it attains simplicity, lightness, and the fewness of parts of the anthracite suction producer which now forms so large a British industry. Returning, however, to the engine difficulties, the large gas-engine may be considered as combining the difficulties of hydraulic engineering work at considerable pressure with those proper to a boiler furnace or flue. The possible pressure to be resisted by such engines cannot be taken as less than 400 lbs. to 500 lbs. per sq. in., and a heat flow through the cylinder and combustion chamber walls has to be provided for greater than that of most boiler furnaces. It is obvious that here we have contradictory conditions involved, which become rapidly onerous with increase of dimensions. Thick castings are required to stand the high pressures, but to allow free heat flow from the flame within the cylinder to the water in the water-jacket calls for thin castings. Engines of small dimensions do not involve any serious conflict, but where metal is required of about 3 ins. thickness to resist internal pressures the temperature difference between the flame and water side of the metal becomes serious, and great stresses are set up which ultimately lead to the cracking of the castings. Great attention has been paid to this phenomenon of cracking, and in existing large gas-engines the difficulty has been partly met by skillful design and special quality of metal used. Although much ingenuity and skill has been spent in this direction, yet it is found that a dimension limit is very soon reached. Cylinders, for example, of 51 ins. diameter have been found to be too large. Nothing but the highest skill in designing and the greatest care in the choice of material and workmanship enables such cylinders and combustion chambers to withstand for any length of time the severe treatment to which they are exposed.

In a paper which I had the honor to read at the Cambridge meeting of the British Association I directed attention to the question of the working fluid of these engines, and described experiments which I had made and engines which I had built with the aim of reducing the mean temperature in order to reduce heat flow. Good results were obtained

these engines, but I came to the con-
on that the methods of reducing tempera-
then adopted did not go far enough. For
last three years I have been attempting
duce maximum pressures as well as tem-
ture without reducing mean pressures in
r to diminish the weight of the engines
a given power and secure moderate th ck-
of cylinders and combustion chamber
ngs. There are several ways of reducing
eratures and maximum pressures with-
reducing mean pressures, but all require
h more accurate knowledge of the proper-
of the working fluid than we at present
ess. One solution of the problem appears
e in compounding, and I am now at work
his. Many attempts have been made to
pound the gas-engine by Dr. Otto, Messrs.
sley, Mr. Butler, Messrs Dick, Kerr, and
and others, and I myself have also at va-
times built experimental compound en-
. No success, however, has yet been at-
d. There is no difficulty in getting some
from the low-pressure cylinder, but the
tional work obtained was always too
l in amount to justify the expense of the
rate cylinder. The lack of success was
ly due to ignorance of the rates of cool-
of the working fluid at different tempera-
and pressures. Experiments made with
d vessels do not give much information
he necessary points. I found it neces-
to make experiments of this nature on
engine itself in its working condition, in-
l of on closed vessels. At the beginning
905 I designed a new method and per-
ed a considerable number of experiments
50-HP. gas-engine, by means of which I
ined a cooling curve in the actual engine
der, and much other information of a
l nature both from the scientific and
practical points of view. Its action was
fied by so altering the valve arrange-
s that at any desired moment both inlet
ge valve and exhaust valve could be held
d, and with this device I was enabled to
diagrams from which a cooling curve could
calculated. One of these diagrams is
n at Fig. 1. It will be seen that
usual charging stroke—compression, ex-
on, and expansion—is performed proper
he four-cycle gas-engine, but when the
ust period approaches, instead of opening
exhaust valve and discharging the gases
e proper point, the valves are all kept
d, and no gases are allowed to escape
the cylinder. The energy stored up in
flywheel accordingly causes the piston to compress the whole contents of the cylinder into the compression space, and the temperature which had fallen by expansion rises again by compression. A point is touched by the indicator pencil on a vertical line at the compression end of the card. On expanding, a line below the first compression line is

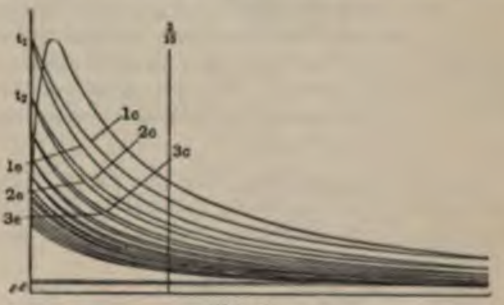


FIG. 1.

drawn, then the next in-stroke traces another compression line. In this way a series of compression and expansion lines are obtained, each terminating under compression at certain specific points. These points are successively lower in order. In this particular diagram it will be observed that before the ordinary compression line of the engine is reached six of these points are marked. If no cooling took place in the cylinder, obviously whenever the volume was restored to any particular point—that is, say, to the volume of the compression space—no fall of temperature would be visible between one revolution and another. The compression and expansion lines would coincide. The fall, as you see, is gradually decreasing from revolution to revolution. This gives an idea of the time taken to lose heat to the cylinder walls with all the engine parts in their ordinary state. The temperature fall from point to point, however, is not entirely due to heat loss. Some of the heat disappears as work done. A certain amount of the heat is converted into work at each reciprocation. This, however, can be allowed for, and a cooling curve obtained which shows the real temperature drop due to cooling upon the expanding and compressing lines. From this curve, by somewhat troublesome calculations which I need not enter into here, the apparent specific heat of the charge can be obtained for each expansion line. Tables I and II have been calculated from the numbers so obtained. These tables clearly show that the apparent specific heat of the working fluid, which consists of the product of combustion in the cylinder of

this particular engine, increases considerably with temperature, so that the instantaneous value is about 28% greater at 1,000° C. than it is at 100° C., while at 1,500° C. the increase amounts to 31%. The mean apparent specific heat between 0° C. and 1,000° C. is 15% greater than it is at 100° C.; between 0° C. and 1,500° C. it is 20% greater. These apparent specific heat numbers enable me to obtain a curve of heat loss to the sides of the cylinder, either for complete double strokes, or for partial double strokes at the inner end of the stroke.

TABLE I.—Apparent Specific Heats (Instantaneous) at Constant Volume in Ft.-Lbs. per Cu. Ft. of Working Fluid at 0° C. and 760 mm.

Temp. Degs. C.	Sp. Heat Ft.-Lbs.	Temp. Degs. C.	Sp. Heat Ft.-Lbs.
0	19.6	800	26.2
100	20.9	900	26.6
200	22.0	1,000	26.8
300	23.0	1,100	27.0
400	23.9	1,200	27.2
500	24.8	1,300	27.3
600	25.2	1,400	27.35
700	25.7	1,500	27.45

TABLE II.—Mean Apparent Specific Heats (Constant Volume) in Ft.-Lbs. per Cu. Ft. of Working Fluid at 0° C. and 760 mm.

Temp. Degs. C.	Sp. Heat Ft.-Lbs.	Temp. Degs. C.	Sp. Heat Ft.-Lbs.
0-100	20.3	0-900	23.9
0-200	20.9	0-1,000	24.1
0-300	21.4	0-1,100	24.4
0-400	21.9	0-1,200	24.6
0-500	22.4	0-1,300	24.8
0-600	22.8	0-1,400	25.0
0-700	23.2	0-1,500	25.2
0-800	23.6	—	—

Fig. 2 shows four such curves. The curves a, b represent the heat losses incurred in complete revolutions—that is to say, in complete double strokes. Here the surface exposed and covered alternately is that due to the whole sweep of the piston. The curves a′, b′ represent losses incurred at the upper three-tenths of the double stroke, while the piston moves from three-tenths stroke to the end, compressing into the clearance space, and then moves out again to the point of three-tenths of the outward stroke. The ordinates give heat loss in foot-pounds to the second and the abscissae mean temperatures per total stroke or double three-tenths stroke. This table gives interesting information enabling approximate calculations to be made dealing with the durability of the working fluid exposed to cylinder surface. It has enabled also important facts to be discovered as to the mean temperature of the cylinder walls and the heat flow with varying density. Curves a, a′ were calculated from experiments made with the engine running without load at 120 r.p.m., jacket water kept at a mean tempera-

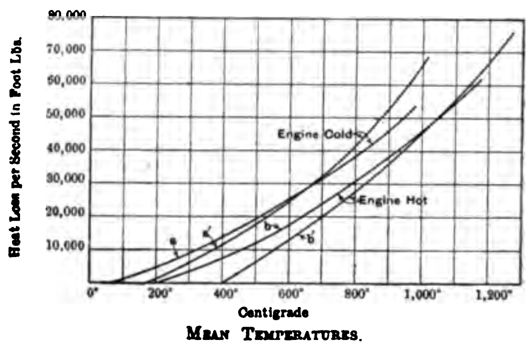


FIG. 2.—HEAT-LOSS CURVES.

ture of 13° C. Curves b and b′ are calculated from experiments made with the engine running at 160 r.p.m. with a load of 150 B.HP. and jacket water at 80° C. The curves are accordingly marked as "Engine cold," "Engine hot." Where the engine is running cold, the mean temperature for the complete strokes of the walls is shown to be about 65° C., notwithstanding that the jacket water is 13°. For the three-tenths stroke, running cold, wall temperature 165° C. With the engine running hot, the whole stroke shows mean temperature of walls 190° C.; for the inner three-tenths, 400° C. These numbers, giving quantitative values of heat loss for a given cylinder, enable the conditions within the cylinder walls to be released with some accuracy. In this particular engine the walls of the combustion space are about 1¼ ins. thick, and calculating the temperature gradient in those walls for the heat flows, given temperature difference, say, 700° C. between gas and interior of the wall, gives a temperature difference in the metal between the water side and the gas side of 60° C. A temperature difference of 1,000° C. between gas and inner wall gives temperature difference in the metal of 104° C. These differences are accentuated with greater metal thickness almost in proportion to the thickness: those with the higher temperature to the last calculation a thickness of 3¾ ins. wall would give a temperature difference in the metal itself of over 300° C. These numbers throw

an important light upon the problem of the large gas-engine, and enable me with some confidence to experiment upon the variations of indicator diagram and the transfer of hot gases from cylinder to cylinder required for successful compounding. The experiments show also many interesting and unexpected facts in connection with the behavior of high-temperature working fluid in these engines. Much remains to be done, however, and I am continuing the investigation on three engines with the object of determining the laws of the working fluid within the gas-engine cylinder more completely.

In modifications of the conditions of the working fluid combined with mechanical modifications of the engine using it, I hope to find in the near future some more satisfactory solution of the large gas-engine problem than at present exists. It appears to me that the problem is one more of working fluid than of pure mechanism. So far, however, the conservative attitude of British engineers toward large gas-engines has been fully justified.

As I have already said, part of the large gas-engine problem depends upon the producer. A bituminous fuel producer of a type suitable for use on shipboard has not yet been devised, and until such a producer is designed and thoroughly tested the anthracite suction producers of today will not allow any great extension of gas motive power to large seagoing vessels. Mr. Capitaine has, I am informed, applied an engine of 300 HP. to a towing vessel on the Rhine, but as yet this movement is in its early infancy.

The great success of the suction producer in connection with stationary engines on land has enabled the power of gas-engines in use to be very materially increased. Tests at the Royal Agricultural Society's show last year have proved that even small producer-driven engines only require 1 lb. of fuel per brake horse-power per hour, including lighting-up and stand-by losses of the producer at night. Other experiments, some of them by myself, show very clearly that with a good suction producer we can obtain 85% of the whole heat of the fuel in the form of inflammable gas ready for delivery to the engine. Many tests have shown that the running consumption of many of the engines at full load does not exceed 0.75 lb. of anthracite per brake horse-power per hour.

So much for the position of the gas-engine at present. I have only a few words to say about petrol engines.

Petrol engines operating on the four cycle by virtue of high speed of revolution are able to give very large power for very small weight, and they give a very fair thermal efficiency considering their small dimensions. Many of their points, however, are in urgent need of careful scientific study. To one point only will I refer, as experiments will throw important light upon the nature of the combustion occurring in these motors. This year the Royal Automobile Club has made a valuable set of experiments, at which I had the honor to assist, upon the exhaust gases given out by these engines under different conditions of running. The experiments clearly proved that, so far as visible smoke was concerned, many petrol engines now running on the road had attained absolute perfection. In these tests, however, exhaust gas analyses were made, and it was found that, although many of the cars burned the petrol given to them in a most complete manner and evolved a minimum of carbonic oxide gas, yet some of them showed percentages of carbonic oxide in the exhaust greater than 2%. It was resolved by the Royal Automobile Club to continue these experiments later in the year; but, meantime, as a matter of interest, I thought it well to examine the exhaust gases of my own car—an 18 HP. "Siddeley." The following results were obtained under different conditions:

TABLE III.

	Percentages of CO in exhaust gases. April 23.	May 7.	July 3.
Engine throttle full open; car climbing hill	3·6	3·6	2·2
Engine throttle less than half open; car running on level	6·9	4·2	2·4
Engine running without load; car standing	0·5	0·4	1·8

From this it will be seen that, as at first adjusted, the carburetter of this "Siddeley" car was supplying an excess of petrol at the higher loads, so that no free oxygen was left in the exhaust. Consequently, carbonic oxide appeared when running with light load of 6.9% and heavy load 3.6%. Successive tests were made as given above. Undoubtedly, as will be seen, by altering the adjustment of the auxiliary air valve, the carbonic oxide was reduced to very nearly 2%. It is highly desirable that the exhaust gases of these cars should contain a minimum of carbonic oxide, in view of the rapid increase of their use in large cities like London. In the open road, a little carbonic oxide rapidly diluted by air would do no harm, but in large cities, when horse traction is replaced almost entirely by

petrol motor vehicles, it will be necessary to look into this carbonic oxide question with great care. It is quite certain that the problem can be effectively solved, because in investigating gas-engine exhaust I have found that a good engine properly adjusted will not produce more than 0.1% of carbonic oxide in its exhaust under any circumstances of ordinary running. The problem is one of the carburetter—a much more difficult problem than appears at first sight. There are many interesting problems to be solved with regard to the petrol engine, but this one of the carburetter appears to me at the moment to be the most pressing.

In this paper I have not dealt with the question of thermal efficiencies at all. The thermal efficiencies of all gas and internal-combustion engines are very high compared with any other form of heat motor. In recent tests by the Thermo-Dynamic Standards Committee of the Institution of Civil Engineers an ordinary "National" gas-engine—the one referred to in this paper—gave an indicated efficiency of 35% and a brake efficiency of as nearly as possible 30%. The efficiency obtained from smaller petrol motors is somewhat less, but in tests made by Hopkinson it rises as high as 24.6%. This is a very high efficiency for small-diameter cylinder.

So far as I understand the question, although large increases in thermal efficiency are still probable, efficiencies are quite high enough at present for all practical purposes, and the main efforts of engineers and scientific men interested in the internal-combustion motor should be directed to the solution of the large gas-engine problem in such a way as to reduce weight and increase power of the unit; to improve the bituminous fuel producer; to apply the improved engine and producer to marine purposes, and overcome the various difficulties there presented; in petrol engines to design carburetters capable of proportioning the charge more accurately than at present under all conditions of running, whether with light or with heavy loads.

CHANGE OF STRUCTURE IN IRON AND STEEL

By WILLIAM CAMPBELL, Ph. D., Sc. D., Columbia University

CONDENSED FROM "THE JOURNAL OF THE FRANKLIN INSTITUTE *

The Constitution of the Iron-Carbon Series.—The constitution and structure of iron and steel have been thoroughly worked out, and with this subject will always be associated the names of Sir Wm. Roberts-Austen and J. E. Stead, in England; of F. Osmond and H. Le Chatelier, in France; of A. Martens and E. Heyn, in Germany; and H. M. Howe and A. Sauveur, in this country, out of a long list of workers.

In the solid state we recognize three forms of pure iron α, β and γ, whose transformation points are 760° and 900° C. The solubility of carbon in γ iron reaches a maximum of about 2%, whilst in α iron it is nil.

To Roberts-Austen we owe the first temperature-composition curve for the series, which consists of the lines A B D, a B C, G O S E, M O and P S K. In his lectures he taught that the alloys of iron and carbon consisted of two constituents in freezing, namely, graphite and a solid containing up to 2% of carbon in solution. That at a lower temperature this solid containing carbon in solution rearranged itself into two constituents, ferrite of pure iron and cementite or iron carbide, just as the series ice-salt changes from the liquid to the solid state on fall of temperature.

The curve for the iron-carbon series was corrected and brought up to date. The point A (Fig. 25) was placed just below 1.600° C., a at 1.2% carbon and 1,120° C., B at 4.3% carbon, G at 890° C., M at 770° C., S at 690°

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*Through the courtesy of the Journal we are enabled to present the illustrations accompanying the original article.

C. between 0.8 and 0.9% carbon. The point E at 1.8% carbon and 1,000° C. formed the summit for the curve denoting the separation of cementite, which falls with increase in total carbon, till at about 4.25% carbon it meets the line S K, and ends. Above 4.25% carbon ferrite separates. The two lines denoting the separation of cementite and ferrite above 2% carbon were hypothetical. Just below the line a B C, a parallel line was drawn at about 1,060° C. on the suggestion of H. Le Chatelier to denote the possible solidification of cementite eutectic in white iron.

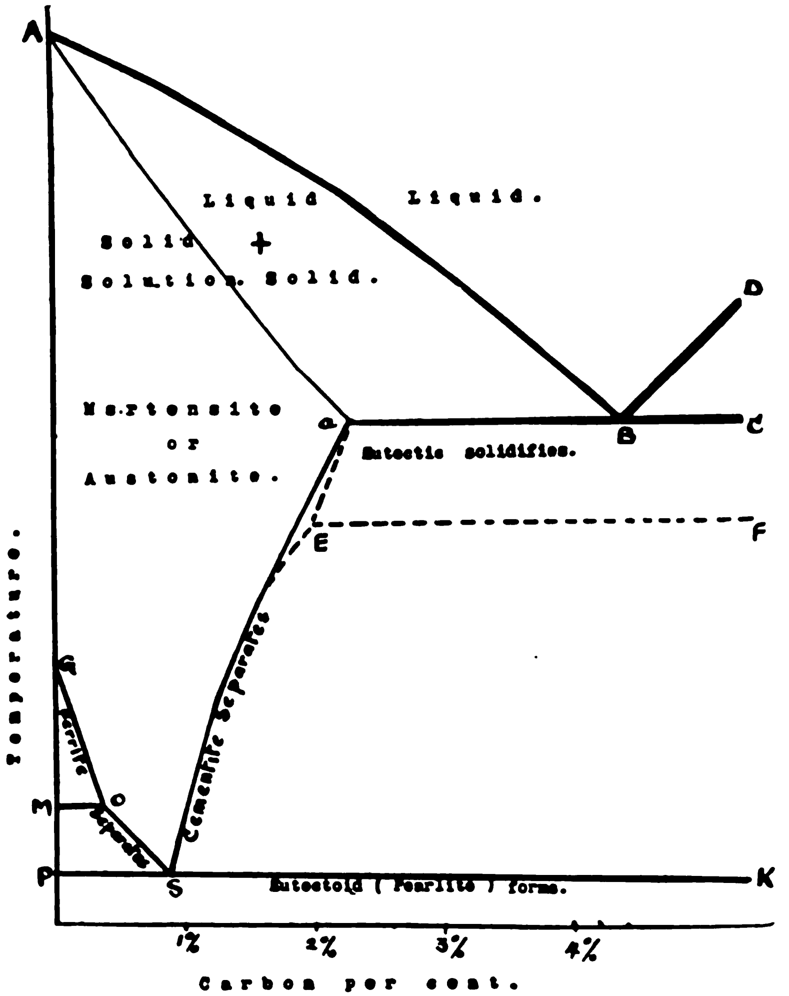

FIG. 25.

Starting with Roberts-Austen's data, Rooseboom for physical-chemical reasons added to the curve so that certain principles of solution were brought out thereby. His modification consisted essentially of adding the lines A a, a E and E F. The beginning of freezing is represented by A B D the liquidus, whilst A a B C the solidus denotes the end of freezing and below these limits the alloys are solid. When a liquid alloy cooled down to the temperature A B dendrites separated out and contained a maximum of 2% carbon in solid solution. These mixed crystals were called Martensite. In alloys containing more than 2% carbon a groundmass, the Martensite-graphite eutectic, makes its appearance and is denoted by the horizontal line a B C. The

branch B C denotes the separation of free graphite. Thus we find that from 0 to 2% carbon the alloys solidify as mixed crystals (solid solutions); from 2 to 4.3% or A to B, the alloys solidify as dendrites of the solid solution (2% carbon) set in an increasing groundmass or eutectic of graphite and the solid solution; whilst above B or 4.3% carbon we have free graphite and the eutectic. Beneath the line A B C at 1,130° C. therefore, we are dealing with a solid conglomerate of two phases, graphite and Martensite, with 2% of carbon in solution. The line a E indicates that the amount of carbon in the solid solution falls with the temperature and we have a further separation of graphite till at about 1,000° C. and 1.8% carbon, the line a E meets the cementite line S E of Roberts-Austen. This means that in the normal state of equilibrium we have an abrupt transformation thus:

Martensite (1.8% C.) = graphite + cementite (Fe₃C). The temperature 1,000° is therefore a transition point, in other words, at this temperature only can we have three phases in equilibrium, and therefore in all alloys the transformation of Martensite and graphite into cementite must occur at this temperature which is denoted by the horizontal line E F. As the temperature falls below 1,000° C. the amount of carbon in solid solution Martensite decreases and we have the separation of cementite along the curve E S. This continues until we reach the line P S K at 690° when the residual Martensite with 0.85% carbon in solution changes over into a conglomerate of ferrite and cementite which we will call pearlite. The formation of this eutectoid pearlite causes recalescence. To sum up according to the work of Roozeboom in slowly cooled iron or steel in equilibrium we should only find ferrite and cementite.

White Cast Irons (Alloys of Martensite and cementite).—The line A B denotes the freezing of crystals or dendrites of Martensite holding a maximum of 2% carbon in solid solution as cementite. The line B D denotes the freezing of crystals or plates of cementite, whilst the line a B c shows the solidification of the groundmass or eutectic of Martensite and cementite. Thus up to 2% carbon the alloys form a series of solid solutions or mixed crystals (Martensite). Between a and B or from 2 to about 4.3% they consist of dendrites of Martensite surrounded by an increasing matrix of Martensite and cementite, the eutectic. Above B or 4.3% they consist of increasing amounts of cementite plates set in the same eutectic or groundmass. Fig. 1 magnified 40 diams., is a section of washed metal containing 1.75% carbon, Si = 0.01; P = 0.012; S = 0.020. It consists of a few dark etching grains of Martensite set in a groundmass which is a mixture of dark-etching Martensite and bright cementite and is the eutectic. Fig. 2 shows a portion of the same under 240 diameters. The alloys occurring on the right of B are illustrated in Fig. 3, which is a section of spiegeleisen very slowly cooled, magnified 30 diams. It consists of plates of cementite (here a carbide of iron and manganese) set in the eutectic of Martensite and cementite.

With fall of temperature below a B c, say 1,125° C., the Martensite becomes supersaturated with cementite, being no longer able to hold 2% of carbon in solution. The cementite therefore separates out along the line a S, which denotes the composition of the Martensite with fall of temperature, till at 700° C., or the temperature P S K, the residue contains 0.85% C. and splits up into a mixture of ferrite and cementite, or the eutectoid pearlite. Hence the final products will be cementite and pearlite, which are the constituents of Figs. 1, 2 and 3, the pearlite appearing black, the cementite white. We have, therefore, three generations of cementite: (1) the constituent of the eutectic which solidified at 1,130° C.; (2) the excess which separated on the line a S; (3) the constituent of the eutectoid pearlite.

Gray Cast Irons (Alloys of Martensite and graphite).—The line A B denotes the beginning of the freezing of dendrites of Martensite, the line B D the separation of flakes of graphite, whilst a B c shows the solidification of the groundmass or eutectic of Martensite and graphite at 1,130°. Thus we have replaced the cementite of our white irons by graphite. There is one other great difference, however. The Martensite which separates out does not have a constant amount of carbon in solid solution. In other words its point a can vary from 2 to [illegible] carbon. As the temperature falls the Martensite [illegible] re-arranges itself into ferrite and pearlite, or cementite and pearlite, or pearlite alone, according as the percentage of dissolved carbon was less than, greater than or equal to 0.85%, following the curves G O S and S a. If we follow the Roozeboom diagram for gray irons, with say 2% combined carbon at [illegible] we have the reaction at E to form cementite, which, of course, is incomplete. When a moves to the left, as it does with increase in

FIG. 1.

FIG. 2.

FIG. 3.

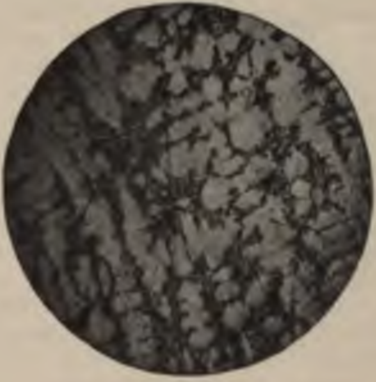

FIG. 4.

FIG. 5.

FIG. 6.

silicon and from other causes, the phase-rule still requires that there should be the reaction: Martensite (up to 2% C.) + graphite = cementite, in order that we may only have two phases. In general this would tend to take place wherever the curve denoting the solubility of graphite in Martensite cuts the line denoting the separation of cementite.

Many observers find that cementite forms in some gray iron right from the solidification point 1,135° C., which would mean the raising of E F till it coincided with a B c.

The structure of the series is well shown in Fig. 4 (magnified 50 diams.), a piece of cast iron with 2.9% C., 1.44% Si, and 0.23% Mn, very slightly etched. Light dendrites of Mar-

tensite are seen set in a groundmass which is the eutectic of Martensite and graphite. Fig. 5 (× 35 diams.) shows the eutectic alloy of Martensite and graphite, a structure of common occurrence in gray pig-iron. Fig. 6 shows the coarsest part of the same specimen under the higher magnification of 120 diams. As before, the Martensite on cooling down rearranged itself by separating out ferrite or cementite, and recalesced at 700° C., forming pearlite.

All irons between white and gray consist of grains of gray surrounded by a network of white, the gray apparently freezing a little ahead of the white.

Stansfield in a paper on the "Present Position of the Solution Theory of Carburized Iron"* comes to the conclusion that graphite does not combine with iron on slow cooling to 1,050° C. and that the 2% of carbon which the iron at first holds in solid solution is rejected as graphite and not as cementite, if the metal is cooled sufficiently slowly. Instead of the line a E denoting the further separation of graphite and cutting the cementite line S E at E, a line a S is drawn to the left of and parallel to E S, so as to cut G O. This new line denotes the solubility of graphite in Martensite which is therefore much less than that of cementite in Martensite. That graphite is not formed in steel, he concludes, is due partly to the absence of nuclei of graphite on which further deposits might take place, partly to the length of time required for the separation of graphite and partly to the mechanical pressure which must oppose the formation of bulky graphite in steel. The phase rule demands that in equilibrium there be but two constituents present. Graphite being the more stable these two constituents must be ferrite and graphite.

THE STRUCTURE AND TREATMENT OF STEEL

Wrought Iron and Steel. When we pass from wrought iron through mild steel [illegible]

which consists of ferrite and long threads of slag. The ferrite occurs in the form of polygonal grains which can be seen in Fig. 8 (× 260 diams.), a piece of wrought iron pipe. The slag is seen to be composite, with lighter grains set in a darker groundmass. When wrought iron is strained beyond its elastic limit, slip-lines are set up as in a pure metal. Fig. 9 (× 80 diams.) shows several systems of parallel slip-lines in a piece of wrought iron with an extremely coarse grain. The section is perpendicular to the rolling, and the round globules are cross-sections of slag. Where the strain is extreme, the slag breaks up as is shown in Fig. 7, which is a vertical section through a test-piece at the point of rupture. The slag has broken up into fragments between which the plastic ferrite has flowed in.

The difference between wrought iron and steel of very low carbon is mainly the absence of slag. Fig. 10 (× 110 diams.) shows some steel with 0.035% carbon slowly cooled from 1,100° C.; it is composed of irregular grains of ferrite, with a few black dots of pearlite containing 0.85% carbon. Its physical properties are:

	Elastic Load. —Lbs. per	Max. Load. sq. in.—	Elongation in 8 ins.	Reduction of Area.
As rolled	23,000	44,000	30%	68%
Annealed at 700° 3 hrs.	28,000	41,500	33%	67%
Heated to 820°, quenched in water	34,000	56,000	9%	77%

Campbell gives an elastic limit of 27,000 lbs. per sq. in. and a maximum load of 46,000 for open-hearth steel running 0.04C. and 0.04 Mn. Annealing such material for a long time at temperatures below 750° C. causes a rapid growth of grain, and the crystals become quite coarse. Reheating to just about 900° C., i. e., G in Fig. 1, causes refining.

An increase in carbon causes an increase in the pearlite with an increase in strength and a decrease in ductility. Fig. 11 (× 250 diams.) shows a steel with 0.10% carbon. It consists of small grains of ferrite with a few black patches which are pearlite with 0.85% carbon. Heating for a long time just below [illegible] causes [illegible] pearlite to segregate and [illegible] the ferrite is absorbed by the surrounding grains whilst the cementite is left [illegible] of the ferrite. A long [illegible] C. also causes a [illegible] whilst heating to just be- [illegible] refining. Above this, [illegible] the coarser the [illegible] where burning occurs. [illegible] very rapid above

FIG. 7.

FIG. 8.

FIG. 9

FIG. 10.

FIG. 11.

FIG. 12.

A rivet steel with 0.10 C., 0.40 Mn, 0.011 P., 0.01 S has:

	Tensile Strength. Lbs. per sq. in.	Elastic Load. Lbs. per sq. in.	Elongation in 8 ins.	Reduction of Area.
As rolled	53,000	37,500	33%	62%
Annealed	50,500	31,000	35%	68%

Fig. 12 (× 260 diams.) show some steel containing 0.16% carbon, which ought to give an elastic limit of about 45—50,000 lbs. per sq. in., and 65,000 maximum load with 21% elongation in 8 ins. and 60% reduction of area. It is not cast steel, however, but is a photo from an area in some so-called puddled iron. The tensile tests showed up abnormally and the microscope revealed the presence of numerous areas of steel. The material is "piled"

[illegible] When we increase the carbon above this point, the excess separates out as cementite [illegible] reducing the [illegible], which coalesces [illegible] with the formation of pearlite as before. [illegible] shows a piece of [illegible] bright, hard veins of [illegible] the pearlite grains, [illegible] pearlite shows [illegible] well [illegible]

[illegible] treatment on [illegible]

[illegible]

FIG. 13.

FIG. 14.

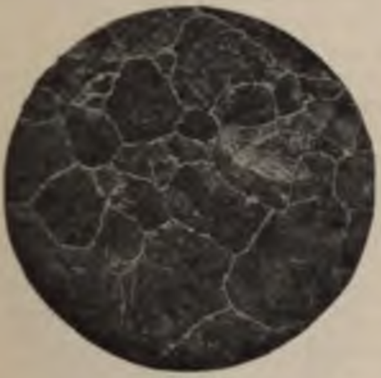

FIG. 15.

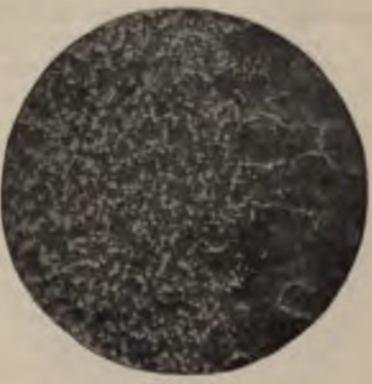

FIG. 16.

FIG. 17.

FIG. 18.

eutectic of iron and carbon is the cementite one and that in the absence of silicon graphite is the product of decomposition of cementite.

Heat Treatment of Cast-Iron.—In the manufacture of malleable castings from white cast iron, on passing 700° C. the pearlite changes over into Martensite: at a little above 1,000 C. the cementite breaks down into ferrite and graphite. Is silicon essential to the process? Most people think so. Tiemann made some silicon-free cast iron with total carbon 4.5, graphite .0255. This material was heated to all temperatures up to the melting point without causing the cementite to decompose. On the other hand, Wüst, with a white iron of 3.8% carbon and not more than 0.008% Si

on heating for 50 hrs. at 980° C. in a vacuum and slowly cooling, produced a product consisting entirely of pearlite, ferrite and temper carbon, the whole of the cementite having decomposed.

An experiment was performed with some pieces of washed metal (3.75 C, 0.03 Si) which were heated to about 1,050° C. in an oxidizing atmosphere. Fig 20 shows a section near the surface of one of the pieces. In the center we have the original white cast iron showing no trace of graphite, whilst around it lies an area of cementite and pearlite running about 1.5% carbon, due to decarbonization. No sign of any graphite was seen. One specimen, however, did show graphite, seen in Fig. 21. On the right lies the original white cast iron, whilst on the left we have material corresponding to about 1.5% carbon steel, well mixed with graphite flakes. Thus in one specimen we found the decomposition of cementite into graphite had occurred, whilst in all the others it failed to appear. This shows that the reaction is not constant under the conditions used, and that sometimes graphite appears, in others the cementite remains undecomposed.

Cementite in solution in the Martensite is certainly stable at these temperatures, as shown by Fig. 18. The process of making blister steel also shows this. Wrought iron is heated to a bright red or white heat in contact with carbon. The iron is in the γ range and Martensite is formed by diffusion. Fig. 22 (× 60 diams.) shows some half-cemented steel which is composed of bright ferrite and darker, coarse pearlite. Fig. 23 (× 260 diams.) shows the same: the pearlite is seen to be extremely coarsely laminated, with a band or border of cementite due to segregation in slow cooling. Fig. 24 (× 260 diams.) shows some fully cemented bar. The black streaks are the original slag of the wrought iron. Slow cooling has produced a coarse pearlite in which are set thick veins and patches of cementite. Thus we can produce a cement steel up to 2% + of carbon without forming graphite, but reheating the same would cause the formation of graphite due to the breaking down of cementite around 1,050° C.

SUMMARY.

From our present knowledge we must judge the cementite-Martensite series to be the unstable one. Absence of silicon and rapid cooling tend to cause white cast iron. When high carbon steels are heated to their melting point and slowly cooled, white cast iron is formed. Pure cast irons with a comparatively small amount (2—3%) of carbon tend to be white.

Gray cast irons are the Martensite-graphite series, which occur with much silicon and slow cooling. The presence of much carbon (3% +) tends to produce a gray iron.

Graphite is formed due to the decomposition of cementite by reheating to temperatures around 1,000° C. In steel a higher temperature (to melting) causes the solution of the cementite or formation of white cast iron. In malleable castings the action is similar, cementite breaking down into ferrite and graphite. Too high a heat retards and even prevents this reaction.

Most cast irons are a mixture of white and gray or cementite, Martensite and graphite, the gray forming a mesh in a network of white cast iron, which forms at a slightly lower temperature. This structure is probably due to the presence of silicon, manganese, phosphorus and sulphur in varying amounts.

The simultaneous occurrence of cementite and graphite in certain specimens of siliconless irons can not be explained satisfactorily except by assuming that we are dealing with two systems:

(a) Ferrite and Graphite,
(b) Ferrite and Cementite,

which Benedicks calls the stable and the meta-stable systems respectively. This does away with the necessity of assuming a reaction between graphite and Martensite to form cementite in the region of 1,000° C., which Roozeboom himself no longer holds.

[In the above paper the name Martensite has, for the sake of convenience, been used in its old meaning, the solid solution of carbon in iron or what is often termed mixed crystals. Now, however, the solid solution is known as austenite, and Martensite is a transition product. Recently Sauveur has dealt with the subject and from his paper we learn that:

Austenite is a solid solution of carbon in γ iron.

Martensite is a solid solution of carbon in β iron. Troostite is a solid solution of carbon in α iron.

Pearlite is the iron-carbon eutectoid, in other words a mechanical mixture of ferrite and cementite. Thus austenite, Martensite,

FIG. 19.

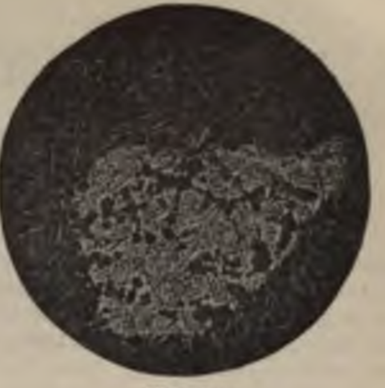

FIG. 20.

FIG. 21.

FIG. 22.

FIG. 23.

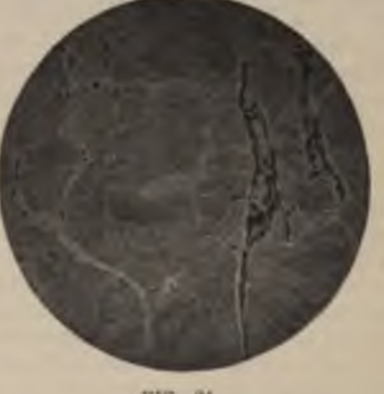

FIG. 24.

troostite and pearlite form a series, Martensite and troostite being transition products between the original solid solution and the eutectoid. Sorbite or the unsegregated form of pearlite would therefore occur between the latter and troostite.]

ELECTROLYTIC REFINING OF TIN.

By OTTO STEINER, Ph. D.

CONDENSED FROM "ELECTROCHEMICAL AND METALLURGICAL INDUSTRY"

While most metals are now being electrolytically refined tin represents an exception. The reason is that in dressing tin ores they are purified to such a degree that the smelting process yields directly very pure tin which does not need any further refining. The small quantities of impure tin which are placed on the market and which have a greater content of foreign metals contain very small amounts of precious metals (½ to 1% Ag). They are used to good advantage for the preparation of alloys.

The first attempt to refine tin electrolytically on a large scale was made by the firm of A. Strauss & Co., in London, in the year 1905, in their smelting works, the Penpoll Tin Smelting Co., Bootle. The process used was invented by Mr. Claus (patented in 1895) and was somewhat modified by me. About a hundred tons of 90% raw tin were refined, and the product was tin of 99.9% purity.

According to the method of Claus, tin alloys are electrolyzed in a 10% sodium sulphide solution at a temperature of 90° C., with a current density of ½ amp. per square decimeter electrode surface at a voltage below 0.2 volt. Tin is stated to be deposited on the cathode in a pure condition, while the foreign metals (Pb, Sb, Cu, Fe, Ag, etc.) are precipitated as sulphides and form the anode slimes mostly attached to the anode but partly accumulating on the bottom of the tank.

THEORETICAL.

If a solution of sulphide of sodium is electrolyzed between two tin electrodes, sulphur is set free at the anode and forms tin sulphide, which dissolves in the electrolyte. The sodium ions are discharged at the cathode, and with a sufficiently high voltage the sodium would react with the surrounding water, forming caustic soda and hydrogen, according to the equation $Na_2 + 2H_2O = 2NaOH + H_2$. This would involve the evolution of hydrogen gas; but since the voltage is kept below 0.2 volt no hydrogen gas can be set free, as the voltage is less than the "Haftintensität" of the hydrogen ion. Therefore, the sodium cannot react with the water, but reacts with the surrounding sulphide of tin according to the equation $2Na_2 + SnS_2 = 2Na_2S + Sn$, so that tin is deposited on the cathode and sulphide of sodium regenerated.

In this way tin is continuously dissolved and Na_2S consumed at the anode and tin is deposited, and Na_2S is continuously regenerated at the cathode. Since the Na_2S formed at the cathode does not at once mix with the electrolyte, but may be seen to flow down the cathode in streams (Schieren), care must be taken to mix the electrolyte thoroughly. This is the best accomplished by heating the bath from below.

The electrolysis takes place without development of gas, if the voltage at the terminals is kept below 0.2 volt. But as soon as this tension is exceeded, even by a small amount, by increasing the current density or by diminishing the concentration of sodium sulphide in the solution, it rises suddenly and automatically up to 0.6 volt, and violent generation of gas with decomposition of the electrolyte takes place. At the same time the cathodic deposit becomes dull, spongy and contains oxides. But it is in practice of great importance to get dense coherent metallic tin on the cathode, since spongy tin cannot be directly melted and cannot be treated without losses in the furnace.

To obtain always compact, metallic tin deposits, I have found that besides the temperature of the electrolyte, its thorough mixing and the maintenance of a low voltage, the following five conditions are of importance:

(1) Only pure tin plates or tin-plated plates must be used as cathodes.

(2) No foreign metals like Fe, Cu, Sb, etc., should be pressed in the electrolyte, either suspended or dissolved or in form of a colloid. These metals have in alkaline solution a lower positive potential than tin, and consequently they are deposited before tin on the cathodic surface, which is rendered thereby unsuitable to receive a dense tin deposit.

A circulation of the solution, such as used in the electrolytic refining of copper, is im-

possible for tin refining. Every tank must be operated independently, and is only in electric connection with the other tanks.

(3) Before suspending new tin anodes with metallic surfaces in cell, it is necessary to dissolve in the electrolyte about 1% of its weight of sulphur, preferably in form of flowers of sulphur. The sulphur forms sulphide at the anode, and since it acts as a depolarizer it is possible to start the electrolysis with low voltage.

(4) Since the electrodes are arranged in this process according to the multiple system, and since the tension (0.1 to 0.18 volt), and, therefore, the resistance are very small, it is difficult to distribute the electric current uniformly over all electrodes of a bath. The slightest irregularity in the resistance of the contacts greatly influences the distribution of the current, and therefore the uniform working of the electrodes. It is necessary to bring all anodes and all cathodes of a bath to the same electrical potential. This can be accomplished in a very simple manner by using sufficiently large cross-sections for the copper bar and for the electrode contacts, so that their electrical resistance is practically negligible.

(5) It is of importance not to interrupt the current during electrolysis, since otherwise the polarization current generates gas at the anodes and oxidizes the cathodes and fouls the electrolyte.

PHOTOGRAPHIC VIEW OF A SAMPLE OF ELECTROLYTIC TIN.
(The piece is bent to show thickness. The cathodes are, of course, straight and flat.)

METHOD OF WORKING.

The electrolyte is preferably 10% Na_2S solution, obtained by dissolving the 60% commercial Na_2S in the necessary quantity of water, settling and, if necessary, filtering.

During electrolysis some of the sodium sulphide is always lost by oxidation of the electrolyte and by formation of sulphostannate. It is therefore necessary to test the solution from time to time and to add some Na_2S. For each 100 kgs. of electrolytic tin produced an addition of about 10 to 15 kgs. Na_2S (counted as Na_2S) is sufficient. The amount of tin in form of sulphostannate in the solution increases continuously during electrolysis, because more tin dissolves from the anode than is deposited on the cathode. At the cathode there is therefore a very slight generation of hydrogen gas, but this is hardly noticeable. The amount of tin in the electrolyte reaches a maximum of about 2.2% Sn after three months. It does not increase any more after it has reached this amount, but remains constant. If the solution cannot be used any more the tin may be precipitated from it by means of sulphuric acid as tin sulphide, and is then converted into SnO_2 by roasting and finally reduced to metallic tin.

The heating of the electrolyte is best ac-

[illegible] indirect[illegible] steam. [illegible] lead coils are used for heating [illegible] the tubes should be of small diameter (exterior diameter not more than [illegible]), since tubes of larger diameter are easily destroyed by strong rushes of water when the steam is turned on. To save heating expenses it is advantageous to cover each tank with a wooden cover and to immerse the [illegible] tubes below the surface of the electrolyte, whereby the evaporation is diminished, and to use the waste steam of the steam engine. The evaporated water is to be replaced [illegible] [illegible] few days.

The anodes are cast of crude metal from raw tin containing not less than [illegible] tin, because the anode slimes remain partly attached to the anodes and increase the voltage [illegible] rapidly if the anodes are too impure. This increase of voltage is the quicker the more impure the anodes are, so that tin anodes with about [illegible] of tin can only be consumed to half the thickness of those of [illegible] tin. If, therefore, metals with less than [illegible] tin are to be refined it is better to mix this metal with purer brands in order to bring the mixture up to [illegible]. Material containing a large amount of iron, say more than [illegible], is not suitable for anodes.

If these anodes are about 75 cms. long, [illegible] cms. wide and [illegible] cm. thick, their weight will be about [illegible] kgs., and the workingmen will be able to handle them without difficulty. The cathodes are cast as very thin plates from pure tin from the previous operation. The weight of a cathode is about [illegible] kgs.

The ampere-hour efficiency is nearly theoretical if short circuits between anode and cathodes are avoided. The temperature of the electrolyte should be at least [illegible]. The higher the temperature the better the deposit. The cathode deposit [illegible] shown in Fig. [illegible] [illegible] [illegible] [illegible] the first time that [illegible] [illegible] deposits of any desired thickness have [illegible] been obtained [illegible].

[illegible]

The current density is about [illegible] amp. per square decimeter anode [illegible] cathode surface. In order to use a higher current density it is necessary to increase the amount of [illegible] in the electrolyte accordingly as the voltage is increased. The distance between the electrodes is preferably made as small as possible, about [illegible] cms.

The tanks are preferably made from iron, since wood gets deformed at a temperature of [illegible]. They should not be longer than [illegible] meters, since otherwise it becomes difficult to distribute the current uniformly over all electrodes of a bath. The conductor bars would have to be made very thick.

The voltage between the electrodes is about [illegible] to [illegible] volt, and the voltage of the whole bath is about [illegible] volt. If a current of about [illegible] amps. is used, as source of power, steam engines are more suitable than gas engines, because steam engines are not liable to cause so many stoppages (see above condition [illegible]), and the waste steam may be used for heating the electrolyte.

The management of the process is as follows: Each tank is operated independently of the other baths. First, the anodes and the straightened cathodes are suspended in the bath, the contacts are soldered and the clear and, if necessary, filtered, solution is allowed to flow in. Then the steam is turned on and at the proper temperature the circuit is closed.

At the beginning the electrode voltage is about [illegible] volt. It increases continuously and will be 0.16 volt after a fortnight. The positive and negative leads of the tank are then short circuited, and the electrolyte is allowed to flow out very slowly by means of a syphon, so that the anode slime is not stirred up.

While the tank is slowly being emptied the electrodes are washed at the same time by the vapors rising from the surface of the electrolyte, so that further washing of the electrodes, involving losses of electrolyte, is unnecessary.

When the bath is empty, the electrodes and the anode mud are removed, new electrodes are introduced, the contacts are made, the electrolyte to which the necessary quantity of sodium sulphide and of sulphur has been added is allowed to flow in, the steam is turned on, [illegible] is removed and the [illegible] [illegible] [illegible]. The cathodes which are taken out [illegible] [illegible] [illegible] directly melted [illegible] [illegible] [illegible] tin results. The anode [illegible] is removed from the anode residues by scraping with a [illegible] and the remaining residues are melted in the furnace.

[illegible] in order to recover the sulphur [illegible] anode slime contains [illegible] Sn. 20 to [illegible] [illegible] [illegible] to [illegible] [illegible] [illegible] [illegible] [illegible] sodium, sulphur and oxygen.

With a current of 1,200 amps. we obtained from every bath during a fortnight's electrolysis from 500 kgs. 93% Peruvian tin about 370 kgs. 99.9% pure tin, 100 kgs. anode slime, 16 kgs. cathode dross and 80 kgs. dross, while 9 kgs. tin remained in the solution as sulphostannate.

About 50% of the tin remains in the residue. It is therefore necessary to use for the above electrolysis about 1,000 kgs. 93% anode tin, from which 500 kgs. will remain as residues and will be melted after finished electrolysis. There are also necessary about 300 kgs. pure tin for the starting cathodes, so that together 1,300 kgs. tin must be suspended in the bath to produce 370 kgs. of pure tin.

The cost of the plant for a yearly production of thousand tons pure tin will be about £5,000.

The expenses of the treatment for producing 1 ton (= 1,000 kgs.) of pure electrolytic tin with such a plant are 135 shillings.

There are to be added at least 40 shillings for losses of tin in the electrolyte, treatment of the by-products and treatment of the anode slime, so that the expenses per ton electrolytic tin will be about 175 shillings. On the other side there is a gain from winning the silver and other metals contained in 1 ton of raw tin of say 115 shillings.

The electrolytic tin refining process will, therefore, only pay if the raw tin can be obtained at a much lower price than the market price of pure tin.

The profit to be expected is very small and a great risk is run in this process, since the price of tin is very unsteady, and because for a yearly production of 1,000 tons of tin a stock of 150 to 200 tons tin is necessary.

But the greatest, nearly invincible, difficulty for this process will be the getting of the raw material, as the whole yearly production of 85 to 93% tin that is put on the market amounts to only about 1,000 tons, and smaller plants will work much more uneconomically.

CARRIAGE TRACTION ON COMMON ROADS

FROM "THE PRACTICAL ENGINEER," LONDON

The tractive force of a drawn vehicle can be determined from the following formula:

$$T = [a + r f + b (v - 3.281)] W \div R. \quad (1)$$

in which

T = traction in pounds of a two-wheeled vehicle—that is, drawn similarly to a common cart. This value is the sum of two calculations for a four-wheeled carriage or wagon.

W = total gross weight in pounds upon the two wheels, including the weight of the two wheels themselves.

R = radius of wheel in inches.

r = radius of axle in inches.

r = radius of chain driving wheel, in inches, of a motor-driven vehicle.

f = coefficient of friction for a lubricated metal axle and box, 0.1. For a lubricated combined wood and metal axle in a wood hub, 0.25.

a = value of rolling constant for wheels with iron tires upon an ordinary macadamized road in fair average condition, 0.26. Corresponding value for wheels with pneumatic or rubber tires, 0.14.

b = value of speed constant for wheels of spring vehicles upon an ordinary macadamized road in fair average condition, 0.025. Corresponding value for wheels on vehicles without springs, 0.087.

v = velocity of vehicle in feet per second.

The value of the axle coefficient of friction f, given above, may, in consequence of better lubrication, due to increased vibration at high speeds of the vehicle, drop down to 0.05 on the journal proper, yet, in consequence of the wheel being jerked sideways against the cap in front, or the flange behind, the higher value

is more certain to be reached, and should be taken in the calculation.

The value of the rolling constant k has been computed from Messrs. Easton and Anderson's traction experiments at Bedford, while the speed constant [illegible] is given by General Morin as the mean result of many trials with numerous vehicles.

The formulas given enables the traction T of a cart or carriage that is drawn or dragged on a level macadamized road to be determined relatively to its rolling resistance, journal friction and velocity. There remains to be considered the correction to T consequent upon the vehicle being drawn up an incline, the resistance due to its being drawn through the air, and also when the vehicle is self-propelled, as in a motor carriage.

In making allowance for extra pull of a vehicle up an incline, let the gradient be spoken of as [illegible] in a distance equal to [illegible]; then the tractive pull is increased because the weight W [illegible] is very approximately increased by [illegible]; also here is the direct lift of [illegible] to add to the traction. So writing T for the additional traction due to the incline,

$$T \quad [illegible] \qquad (2)$$

In examining the resistance offered by the air, only the speed of the carriage need be considered, as the wind sometimes is helping the carriage forward, at other times in front checking its progress, but generally blowing at some angle to the earth's surface, and striking the carriage corner or angle-wise. The pressure of the wind, or rather the resistance to the motion of the carriage through the air in lbs. per sq. ft. of its frontal surface, equals the velocity of the carriage in miles per hour, multiplied by [illegible], or in feet per second, multiplied by [illegible]. Let the resistance per square foot multiplied by the effective frontal area of carriage equal P, and writing T_a equal to the additional traction due to this resistance, then

$$T_a \quad [illegible] \qquad (3)$$

In self-propelled vehicles of the motor class, the pull on the driving chain, or the radial [illegible] induced by wheel gearing, produces an extra pressure on the bearing, equal in chain drive very approximately to

$$T + T_1 + T_2 \quad [illegible]$$

denoting the additional traction due to this cause by T_3, whence

$$T_3 = [illegible] \qquad (4)$$

The writer has now examined in a practical manner all the resistances opposed to the motion of a vehicle, viz., the resistance from rolling, journal friction, speed or velocity of motion, gradients, air, and motor drive. He does not claim to have exactly or exhaustively examined the subject of traction, as to have attempted to do so would have involved the use of formulas of such complexity as to completely nullify their utility, for nothing can be simpler than adding all the separate tractive resistances together, and so obtain the total. Let this total be denoted by T_t, then

$$T_t = T + T_1 + T_2 + T_3.$$

Example.—Find the tractive pull of a motor car of one ton gross weight, on springs, to travel at a speed of [illegible] miles per hour upon a gradient of 1 in [illegible], weight assumed equally distributed upon four pneumatic or rubber tired wheels, driving wheels [illegible], and fore-carriage wheels [illegible] ins. diameter. Chain-driving wheel 12 ins. diameter, axles [illegible] ins. diameter, frontal area of car exposed to the wind 30 sq. ft.

The tractive pull of the fore-carriage axle—

$$\begin{aligned} T_t &= T + T \\ &= [illegible] \end{aligned}$$

The tractive pull of the driving axle—

$$\begin{aligned} T_t &= T + T + T_2 + T \\ &= 49.2 + 35.6 + 2[illegible] + [illegible] \end{aligned}$$

Thus the total traction is equal to 2[illegible] lbs., equal to 7.4 effective or brake horse-power.

In obtaining the necessary horse-power for propelling a vehicle, by the rules given in this article, a good percentage must be added to the calculated result to cover contingencies of bad roads, foul weather, etc.; for to maintain the same speed under bad conditions, would double or treble the calculated horse-power as obtained above.

THE ELECTROLYTIC LIGHTNING ARRESTER

R. P. JACKSON

FROM "THE ELECTRIC JOURNAL"*

The most recent development in devices designed to protect electrical apparatus from over-voltage due to lightning or other sources of disturbance is the electrolytic or aluminum cell arrester.

It has long been known that an electrolytic cell made up of two plates one of which is aluminum and the other carbon or some metal other than aluminum combined with a suitable electrolyte, possesses peculiar assymmetrical characteristics. Current will flow freely in one direction through such a cell while in the opposite direction but a very small current can be produced until the applied voltage reaches a certain value. After such voltage has been exceeded, however, the current increases much more rapidly than the impressed E.M.F. would indicate according to Ohm's law. It was known also that the seat of this peculiar action was in a very thin dielectric film on the surface of the aluminum plate. If both plates were made of aluminum a device was formed which had an action quite analogous to that of the safety valve on a steam boiler in that little or no current, either alternating or continuous, would pass so long as the electrical pressure was kept below the critical value. If, however, the pressure exceeded this value a very large current would follow which would cease to flow as soon as the voltage or electrical pressure resumed its original lower value.

FIG. 1.—PART OF 50-TRAY ELECTROLYTIC LIGHTNING ARRESTER UNIT.

Such a characteristic is an ideal one for protecting electric circuits against over-voltage and its attendant dangers. The present electrolytic lightning arrester represents a commercial form of the above device as adapted for use on circuits of from 4,000 to 60,000 volts. With present known and commercial electrolytes about 400 volts represents the maximum which the film will sustain, so it is necessary to use a large number of such cells in series. Practically, on alternating-current circuits, it is necessary to operate the cells at from 250 to 280 volts each to allow for the maximum of the E.M.F. wave.

The simplest form in which a large number of plates can be arranged in series and yet not have a path through the electrolyte from

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the first to the last plate is to assemble them in tray form so that one may rest within another, insulated from each other, but all containing the electrolyte. Fig. 1 shows how this is accomplished in the electrolytic lightning arrester. A tray unit built up in this form will withstand an effective voltage of

FIG. 2.—ELECTROLYTIC LIGHTNING ARRESTERS IN SERVICE ON A 60,000-VOLT GROUNDED NEUTRAL TRANSMISSION LINE.

13,500 volts with a suitable margin of safety. The whole is enclosed in a stoneware jar for mechanical support and protection and each jar is provided with a suitable top so that one jar may be placed upon another for higher voltages than one unit will sustain. The electrolyte being poured in at the top of the jar fills each tray in succession from the top down and the surplus runs out at the bottom. Transformer oil may then be poured in which follows the electrolyte and forms a film of oil over all the exposed surfaces. This covering of oil prevents the solution from coming in contact with the air and thus practically obviates all evaporation under normal conditions of operation.

Fig. 2 shows three units arranged in form suitable for service on a 60,000-volt grounded neutral transmission line. If connected directly to the line the slight leakage current will cause considerable heat which will evaporate the solution and soon damage the plates. If, however, a gap is placed in series of such a nature as to have some ability to suppress an arc, such a gap may be set very close to the breakdown value at the operating potential In commercial apparatus for potentials above 13,000 volts this gap takes the form of two diverging horns similar to that commonly known as the "horn arrester."

When thus arranged in series with a suitable "horn" air gap the electrolytic lightning arrester has all of the qualities of a safety valve as applied to electric circuits. At the ordinary operating potential it takes no current whatever, but as soon as any abnormally high potential surge or wave appears it permits, through its freedom of discharge, a sufficient flow of energy to maintain the potential of the circuit at practically the value at which the device begins to take current, i. e., to discharge. As soon as such a wave has passed, however, the arrester at once ceases to take current. Moreover, such a very small power current is taken during discharge that the other parts of the circuit are not disturbed in any way as in the case with arresters which at the time of discharge take a large power current.

From the present data it would seem that some form of the electrolytic lightning arrester represents about the limit of effectiveness attainable in such devices so long as dependence is placed on a single set of apparatus in the station to protect against all disturbances.

THE FUNDAMENTAL PRINCIPLES OF ARTIFICIAL ILLUMINATION

CONDENSED FROM "ENGINEERING NEWS."

There are a few rules of practice, consistent with the fundamental idea of good lighting, worth summarizing, which are entirely comprehensible to the average engineer. If these rules were more widely recognized, and more rigidly adhered to, the general advance of the art of illumination and the decrease of eye troubles, traceable to poor illumination, would be accelerated.

Illumination may be divided generally into two classes, which we may term the useful and the decorative. As extreme cases we may name the lighting of a drafting room and street decoration. It is not usually possible to entirely separate the two classes so completely. Many cases where the illumination is primarily useful, must have a certain small amount of attention paid to decorative effects. It is often desired, for instance, to so light a parlor or dining room that a required amount of illumination shall be placed where needed and yet with artistic, pleasing or even striking effects.

Color.—The color value of the light given off by the source to be used should approach that of sunlight. A strict adherence to this is difficult, especially with the older lights, though the trouble on such an account has constantly decreased. However, less trouble results from poor color values than from other and less excusable defects. The eye seems to be least fatigued by an excess of yellow and green. This is noticed in comparing the use of dull incandescent filament lamps and mercury vapor arcs in shops.

For house lighting, when a soft decorative light is especially sought, the yellows and oranges may be caused to predominate, by using colored shades or as ingenuity suggests.

Direction of Light.—The eye is accustomed to light coming upon closely viewed objects obliquely from above. By such an arrangement, direct light cannot strike the retina of the eye and directly reflected light is least apt to do so. If direct or directly reflected rays, from a source of even moderate intrinsic brilliancy, do enter the eye, at least a temporary paralysis of the retina and optic centers will result. For this reason, illuminants must not be in the ordinary fields of vision, or if such an arrangement be impossible they must be screened and shaded in the best way that presents itself.

Direct reflection into the eyes from dead light colored surfaces, as well as from bright polished ones, should be prevented. Many eye troubles are caused by direct reflection from papers in the office and home. The special or additional lights for reading, writing or similar work need to be far enough back of the worker so that the directly reflected rays do not come towards the eye. The old familiar rule of having light for such purposes come obliquely over the left shoulder is good.

Diffusion.—Considerable diffusion must be secured. This necessity is obvious when one considers the painfully sharp contrasts of bright surfaces and deep shadows in the now obsolete systems of interior lighting with open arcs. It will be remembered that the replacement of the open arcs by the enclosed type, having a greater degree of diffusion, always brought some relief. The replacement of the latter, in turn, by diffusion-reflected arc and by vacuum tube lights, has been further beneficial.

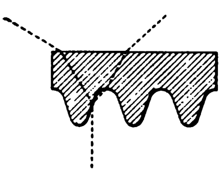
On the other hand, complete diffusion and the elimination of shadows must not be accomplished. With such a condition attained, the usual effects of light and shade are destroyed and the eye overworked to distinguish form and dimension.

Shades and Globes.—It is a fairly well-established principle that light from a bright image should not fall directly upon the retina of the eye. This rules out bare incandescent filaments, glowers, or mantles. With incandescent filament lamps the shades should be so deep that the lamp is well inclosed. The proper use of shades is hygienic, and it always enhances the artistic effects.

The function of a shade or globe should be two-fold: simple diffusion, and a redistribution of rays in more useful directions.

Common crystal and cut glass are usually to be avoided, as they do not eliminate bright spots and often their prisms deflect the light in useless directions.

One of the most useful as well as highly artistic shades that can be employed is the "holophane" type. The advantage in the use of "holophane" globes lies in their scientific and calculated construction. The diffusion and redistribution of light, left to chance in the cheaper forms of allowable shades, is here designed. The interior of the globes or shades is made up of a series of symmetrical longitudinal prisms which diffuse as shown in Fig. 1. The exterior consists of a series of lateral prisms of the general nature indicated in Fig. 2. No two of these prisms are quite alike. Their function is to redistribute the light. The entire surface of the globe or



ENG NEWS.

FIG. 1. INTERNAL DIFFUSION PRISMS OF HOLOPHANE GLASSWARE.

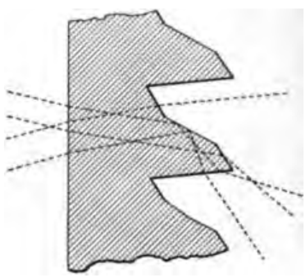


FIG. 2. REDISTRIBUTION PRISMS OF HOLOPHANE GLASSWARE.

shade is an even-toned source of light, due to the effects of both kinds of prisms. There is another advantage quite as great: the small absorption of light by these globes, shades and reflectors and the relatively higher efficiency of effective illumination over that resulting from use of common opal glassware.

The accompanying table will give a basis for the reduction of effective candle power for lights behind glass. It does not show redistributing effect, nor the reflection in certain directions when the lamp is not fully enclosed.

Thickness of glass may, in individual cases, vary these figures which are averages of many tests on globes from various sources.

ABSORPTION OF LIGHT BY GLASS.

	Per cent.
Clear	5-10
Alabaster	10-20
Ground	20-30
Sandblasted	10-30
Opal	20-60

The average of numerous tests on holophane globes, fully enclosing a lamp, indicates an absorption of about 12 per cent of the total light. The best any cheaper satisfactory globe can show is about 20 per cent. with sandblasted ware.

The Amount of Light.—For brilliant interior lighting or bright house effects, an illumination of ½ candle-foot may be arranged. For more moderate and economical uses, such as we would ordinarily expect in the home, ¼ or 1/5 of a candle-foot will furnish a satisfactory general illumination, which, however, will not be strong enough for reading or for similar employment. It must be strengthened to a value of from 1 to even 4 candle-feet, depending on the nature of the occupation. Such a reinforcement may be a local one, by a well-shaded drop or reading lamp.

In special cases, the general illumination of ½ candle-foot is to be increased. In a ballroom for unusually brilliant effects, this figure may easily be 1 candle-foot. Drafting rooms have been designed for 8 to 14 candle-feet, and a minimum of 5 seems necessary for such close work.

An arbitrary unit of illumination has been used for several years, known as the "candle-foot." It is derived from the unit of intensity and unit of length. Thus, one candle-foot indicates the illumination that would result from a source of 1 c. p. at 1 ft. distance. For any intensity of source, the illumination at 1 ft. distance is, of course, numerically the same number of candle-feet as the candle power of the source.

For a distance of more than 1 ft. the illumination varies inversely as the square of the distance. If we double the distance we quarter the illumination. This law is exactly true only in the case of light radiating from a point into space without reflection and refraction. It would apply within a small limit of error to a room with dead black walls, lighted with a single candle. In a room with light colored walls and a distributed arrangement of lamps we must consider the effects of such. In the latter case the law of inverse squares forms a basis on which to work, but it is not to be considered at all exact. The law, as above stated, applies to surfaces normal to the direction of the rays of light. Expressed as a formula this would be:

$$\text{Normal Illum.} = \frac{\text{C. P.}}{D^2}.$$

The case is illustrated by the surface "N," Fig. 3. For horizontal illumination, as that

on a surface "H" (Fig. 4), this formula should read:

$$\text{Horiz. Illum.} = \frac{\text{C. P.}}{D^2} \cos A.$$

when the angle "A" is that one included between a vertical and a straight line from the source to the place where value of the horizontal illumination is desired.

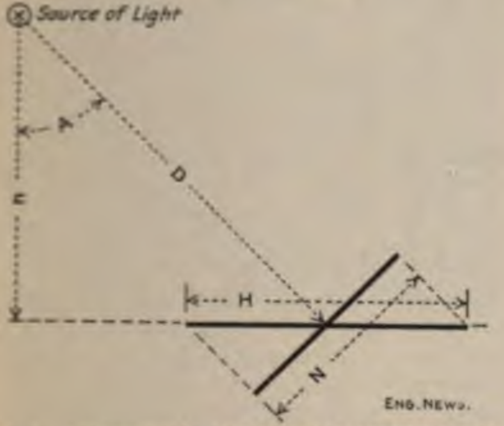


FIG. 3. HORIZONTAL AND NORMAL ILLUMINATION BY DIRECT LIGHTING.

It is sometimes more convenient, knowing the height (h) of the lamp above the horizontal plane of the given surface, to measure or closely estimate the angle "A" than to find the distance "D." By a simple trigonometrical process the formula becomes now:

$$\text{Horiz. Illum.} = \frac{\text{C. P.}}{h} \cos^3 A.$$

In interior lighting design there are three factors which enter the calculations. These are the intensity of the source, the distance to the lighted surfaces and the diffusion and reflection effect. We have shown the law governing the first two. The last depends on the nature of the finish and fittings of the room. If the woodwork be dark and the wall finish soft and of the darker tones, then the effective illumination, on, say, a printed page, is closely that number of candle-feet received from each source, as computed by the law and formula stated above. The effect of globes and shades would, of course, modify the rated candle power, as shown in the paragraphs on those fittings.

If the ceiling and the walls are not of the darker tones and softer finishes, then their reflection and diffusion effect on the lighted surface may be stated very approximately as: Candle-feet

$$= \text{C. P.} \left(\frac{1}{D^2} + \frac{C}{D_c^2} + \frac{W_1}{D_1^2} + \frac{W_2}{D_2^2} + \frac{W_3}{D_3^2} + \frac{W_4}{D_4^2} \right)$$

where C, W_1, W_2, etc., are the coefficients of diffused reflection for the ceiling and four walls. This coefficient represents the effect each surface would have in increasing the effective candle-feet, due to the first reflection.

This method is shown by Fig. 4, for the effect of the ceiling and two walls. The effect of the other two walls would be shown on a plan of the room. The distances D_c, D_1, D_2, D_3, and D_4, are the total distance along the path of the reflected ray to the light source. When lights are well grouped they may be considered as a single source without increasing the error of the final results.

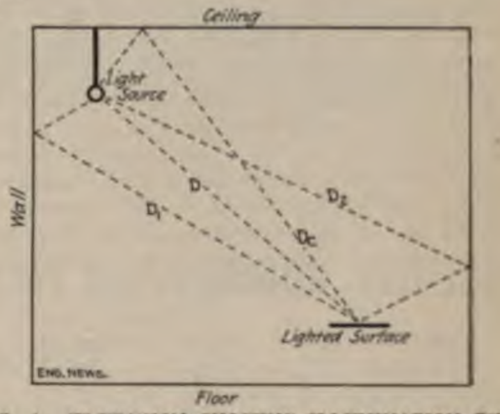


FIG. 4. ELEVATION SHOWING ILLUMINATION BY SIMPLE REFLECTION FROM WALLS AND CEILING.

The accompanying table will show the maximum reflection effects we may expect from wall papers. Other wall finishes in general will increase or diminish the value of the reflection constant as they have relatively a harder or softer surface than paper. These results are not directly the results of tests, but are adaptations from various sources, and are only approximate:

REFLECTION OF LIGHT FROM WALL PAPERS.

Paper.	Reflection, Per ct., C.P.
Soft white	80
Chrome yellow	60
Orange	50
Dull yellow	40
Pink	35
Blue, normal bright	25
Normal green	20
Light brown	15
Dark brown	12
Vermillion	12
Green blue	12
Dull blue	12
Ultramarine blue	3

In considering reflection by this method, (Fig. 4), the candle power of the source along the direction D_c may be decreased by the globe-absorption, and that along D_1, D_2, etc.,

may be increased by the reflection of the globe, if any. Both these are best obtained from a mean photometric curve for the particular arrangement of lamp and shade. Such curves are usually obtainable from the best lamp and shade makers.

In many installations it is not worth while to pay too much attention to the attempted approximation of reflection effects. With the usual-sized rooms in large residences, having throughout the most favorable conditions for reflection and diffusion, with a minimum absorption, the increase of illumination on a given surface may be placed as high as 150 per cent. Such conditions include an unbroken or unpanelled ceiling of alabaster finish, not more than 20 ft. from the floor; walls of a very light tint and a moderately soft finish; woodwork of ivory or colonial white; openings and pictures not having a large percentage of wall area; draperies, light in color and texture; furniture simple, light-colored, and the room not overcrowded with even such.

These conditions are not reached in most arrangements. With ceilings, walls, furniture and draperies of the prevalent types, but of the lighter colors throughout, we cannot expect more than a 50 per cent. total increase of the direct illumination from the light sources. This value of 50 per cent. would fall nearly to zero with dark burlap walls, dark wood finishes, a panelled, somber ceiling and furniture of the dark mission styles. Where calculations of reflection are not to be undertaken, it must be left to individual judgment as to what value to assign these helpful effects between the common 50 per cent. and zero, or where the 50 per cent. may be exceeded, all depending on the prominence of color, finish and furnishings as outlined.

FIELD OBSERVATIONS OF ORE DEPOSITS

By S. F. EMMONS

(FROM THE "MINING AND SCIENTIFIC PRESS")

The first task of a geologist in examining a mining district is to obtain as clear and accurate an idea as possible of its structure and geological history. If it is impracticable to make an exhaustive study, he should at least endeavor to trace the important dynamic events that have brought about the existing structure. It may be assumed that, with rare exceptions, ore deposits are the result of concentrations, often many times repeated, by waters circulating within the rocks, of materials previously disseminated in a less concentrated form elsewhere. Such circulating waters always tend toward channels which admit of more ready circulation, what Van Hise calls "trunk channels," and these channels have in most cases been produced by dynamic stresses; it is evident that their study presupposes a knowledge of the orographic history of the region.

Furthermore, as a general rule, the various processes attendant upon ore deposition tend to obliterate structural and textural features of the rocks and often one can only study these features satisfactorily at some little distance from the actual ore deposits.

The phenomena to be observed fall naturally into three classes, though their observation may be simultaneous: (1) Mechanical; (2) mineralogical and chemical; (3) economic or commercial conditions.

The first have to do with the water-channels, hence with the form and probable extent of the ore bodies. The second, with their mineralogical composition and the nature of the chemical processes which resulted in their deposition; the third, with the extraction of the ores and their subsequent reduction to the metallic condition.

MECHANICAL PHENOMENA.

1. Vein-fissure Fracturing.—The most evident result of mechanical stresses on rock-masses is the formation of fractures or fissures, which when mineralized may form veins. These fissures are in general, strictly speaking, fault-fissures, though the displacement is often so slight as to be imperceptible.

On the other hand, large structural faults are not often found to be mineralized sufficiently to form ore bodies. Some writers on ore deposits speak of vein-fissures as sometimes resulting from contraction, but I have yet to learn of a well authenticated instance. I regard a certain amount of movement as necessary to break the cohesion between the respective walls of a joint or fissure sufficiently to make a water-channel. This I hold to be true also of eruptive contacts. Observations bearing on these points are useful. It is to be noted that a contraction-fissure could not extend from one rock into another.

2. Direction of Fissure-planes.—The direction of fissure-planes, both in dip and strike, and their relation to the general joint or fissure-systems of the region should be determined; but it should be borne in mind that in nature fissures are not mathematical planes but more or less warped surfaces. The average direction of a given system must be determined from as large a number of observations as possible; a few, however accurately determined, will not necessarily give the true direction.

3. Periods of Fissuring.—Find out whether there has been more than one period of fissuring; whether one set of veins crosses and throws another. Here caution is necessary, for there may be an apparent throw produced by contemporaneous fracturing. A vein may end against another and be apparently continued on the other side at a given offset, but if the latter has faulted the former there should be internal evidence of movement in the vein material, and other veins of the same system should be faulted in like manner and amount. The burden of proof is on the faulting. If the evidence is conclusive, the second period of faulting should be correlated with some known dynamic movement of the region.

4. Post-mineral or Secondary Fissures.—It is important to look for evidence of recent or post-mineral faulting that may be connected with secondary enrichment of the deposits; where, as is often the case, this is parallel, or nearly so, to the plane of the vein, it is sometimes difficult to detect. It may show merely as a clay selvage; it may be a distinct breccia zone carrying fragments of ore, quartz, and country rock. The criteria are ground-up fragments of ore, and moisture that evidently comes from the surface; unless one of these is present one can not be sure of its secondary nature. If the country rock is feldspathic, there is often kaolin-mud in the secondary fracture.

5. Character of Fissure.—In regard to the character of the fissure; it may be a single strong fissure, or a combination of parallel fractures, which may be sufficiently numerous to constitute a shear-zone. In the case of the single fissure the vein material is more likely to be the filling of an open space and to be enclosed within well defined walls. Even in this case, however, there are likely to be fragments or sheets of country rock that fill a considerable portion of the space between the walls, and one must observe closely whether the vein material is not in part the replacement by quartz or metallic minerals of some of this dragged-in material. Cross-cuts in either wall should also be observed to see whether the supposed wall is actually the lateral limit of mineralization, or if there are not mineral-bearing fisssures behind it.

6. Fissure Zones.—In the fissured zones the ore is more likely to be a replacement of the country-rock by mineral solutions eating outward from the crack or fissure, in which case the walls which define the lateral limits may be wanting. When the ore follows for a certain distance one fissure, then passes by a cross-fissure to another nearly parallel, but set off a little to one side, and so on, it constitutes a "linked vein."

7. Influence of Country-rock.—The country-rock has some influence on the character of the vein-fissures. Where it is a homogeneous mass the vein systems are likely to be regular; but in passing from one rock to another the character of a given fissure may change. The character of such changes should be noted. In passing from a rigid rock to a plastic one a wide vein may pinch to a mere crack.

8. Indistinct Fissures and Mineralized Dikes.—There may be nothing that one could strictly call a vein along the zone of fracture; simply a shattering of the rock and an impregnation or replacement by silica or vein minerals. This is likely to occur in silicious rocks. Not infrequently there has been a first intrusion of igneous rock in dike form along such a fracture and subsequent movement within the dike which is usually so decomposed in the vicinity of the orebody as to be little more than a mass of clay. Such occurrences require following out along the strike to some less altered region and the detailed study of intersections for a determination of actual relations.

9. Ore Chimneys.—What the miner calls a "chimney of ore"—a body of a rudely circular cross-section—is apt to be difficult to characterize. Sometimes it is a fairly solid mass of

metallic minerals; sometimes they simply form the cement for breccia fragments of country-rock, in either case largely by replacement. I have generally been able to account for such bodies as zones of more or less shattered rocks at the intersection of two or more fracture-planes. Such planes may be difficult to recognize in the immediate vicinity of the ore, being obliterated by the action of mineralization, but they can generally be found in the neighborhood.

10. Orebodies in Limestone.—Because of their solubility the channels that admitted the solutions to rocks like limestone are often difficult to trace; the ore is more likely to be a replacement than a cavity-filling. Cases do occur where it is the filling of well defined fissures, and occasionally of open caves. In such the bands of successive deposition or "crustification" should be recognizable. Existing caves can often be proved to be of later formation than the ore. Bounding bodies of more or less pervious rock will have an important influence upon the circulation of solutions and this influence should be studied. When the solutions have passed along a given fracture or joint-plane and then crossed to another their track may be difficult to follow. In one place a large chamber of ore may have been formed, and this may be connected with another by a crack so small as to be scarcely visible. It is in the unreplaced or barren portions of the rock that one can best detect the fracture-systems. In bodies of replacement in limestone the ore generally grades quite slowly into unreplaced rock with no defined boundaries. In the midst of a large body of unoxidized ore one can generally trace, along the walls of the drifts that have been opened long enough to allow the dust to accumulate on the walls so as to deaden the metallic luster, the bedding and joint-planes of the original limestone, and sometimes, in the roof, the crack through which the mineralizing solutions entered.

11. Ore in Limestone Near Intrusive Bodies.—Where large bodies of igneous rock have been intruded through or across limestone beds and mineralization has ensued, caught-up fragments of limestone wholly or partly enclosed in the igneous rock are often so completely replaced by ore that no limestone can be found. One may detect, however, some relics of the rock structure or some of the lime-silicate minerals into which the limestone has been transformed. Where there has been faulting near the contact of limestones and igneous rocks, mineralization often takes place in the fault material; interstices are filled and limestone fragments replaced.

12. True Contact Deposits.—Finally, there are ore deposits in limestone in the vicinity of large masses of crystalline eruptives where no related fracturing or joint systems can be traced. Ore minerals are associated with contact minerals, such as amphiboles, garnets, vesuvianite, etc., and magnetite or specularite are mixed with pyritous minerals; the ore-bodies are extremely irregular in form and have no definite boundaries; they are often crossed by dikes of eruptive rock that are neither mineralized themselves, nor have appreciably disturbed the orebodies. To these has been ascribed a probable pneumatolitic origin and the name "contact deposits" proposed. When such are observed they should be studied with special care.

13. Observations in Mines.—If one has occasion to examine a mine with extended workings, one should first study the map of these workings and endeavor to form some idea of the underground structure from such trustworthy information as may be given. One should take into the mine with him a copy of the drifts he has to examine, or a rough reduction thereof made in his note-book. In his journeys through the mine, let him keep mental account of the structure and of the bearing upon it of the phenomena observed. If they do not fit the hypothesis adopted, let him stop from time to time and reason out what other conception they better fit. Before leaving the place, let him construct cross-sections to graphically test his hypothesis. If it has not accurately measured data, let him get the best approximations available. Thus, he will often be able to decide where the critical points lie and to settle the question by a final visit; whereas, if it were left until he returns to the office, it might necessitate waiting until another season before the decision between the two alternative hypotheses could be arrived at.

CHEMICAL AND MINERALOGICAL PHENOMENA.

It is assumed that the geologist is familiar with the more common ore minerals and with their appearance in ores, which often differs considerably from what is ordinarily seen in mineral collections.

14. Zones of Oxides and Sulphides.—In examining a mine he will note the zone that separates the original deposit, the sulphides, arsenides, antimonides, and tellurides, from the oxides, carbonates, and sulphates, which

have resulted from their alteration by atmospheric waters; he will see whether there has been any enrichment or impoverishment of the ore above or below this line, any segregation of the metals by migration, and endeavor to trace the causes thereof. It sometimes happens that a mineral occurs in the oxidized zone whose corresponding original is not found in the lower zone. For instance, oxide of manganese, whose original form would be the carbonate or silica, rhodochrosite, or rhodonite.

15. Iron Deposits.—In iron deposits one should endeavor to determine whether they result from the oxidation of sulphides or were originally deposited as oxides. In the latter case if they occur in igneous rocks, let him look for evidence that they were formed by magmatic differentiation, and if such evidence is found, let him also search for evidence of subsequent concentration by aqueous agencies. If in sedimentary rocks, let him see if they have been formed by a concentration of disseminated material by surface or other waters, or are simply residual deposits.

16. Copper Deposits.—In copper deposits it may be assumed as a general rule that the original form of the deposit was chalcopyrite associated with more or less iron pyrite; generally more. Enargite is also an important source of copper which so far as known at present is an original mineral. Evidence bearing upon this point is valuable.

17. Silver Deposits.—In silver deposits this metal is generally associated originally with iron, lead, and zinc sulphides; also with copper sulphides and sulpharsenides. The less valuable minerals are likely to much exceed in bulk the silver minerals, the latter very frequently being indistinguishable except under the microscope. If there are large bodies of very rich silver ore not far below the zone of oxidation there is reason to suspect secondary enrichment and to look for evidence of it.

18. Gold Deposits.—In gold deposits it is important to ascertain whether the gold was originally in the form of telluride, for in this case the cost of reduction is likely to be much increased. This is difficult unless the ore is exceptionally rich so that the tellurides are visible to the naked eye. Make note of any trustworthy analyses and bring in material for chemical and microscopical tests.

19. Secondary Enrichment.—It is important to look for evidence of secondary enrichment, as this may afford criteria for judging of the probabilities of the continuance of payore in depth. It is based on the broad general fact that the sulphates formed by the oxidation of sulphides near the surface are leached down, even into the unaltered portion of the deposit, and in the presence of relatively large masses of iron sulphides will be reduced and re-deposited as sulphides. In this process segregation of the metals may take place according to the differing solubility of their sulphates and their affinities for sulphur. Climatic conditions and the amount of erosion that the region has been subjected to have a bearing upon the process. The favoring structural conditions have already been mentioned. Some of the mineralogical indications follow:

20. Copper Deposits.—In copper deposits, the richer sulphides, chalcocite, bornite, and covellite have been found in most cases to be secondary enrichments of chalcopyrite. The amorphous black ore often occuring near, the line between oxides and sulphides, sometimes called "sooty" ore, is definitely the result of leaching down and re-precipitation. It has hitherto generally been called "black oxide" or "oxysulphide," but chemical examinations of specimens tested thus far have proved them to be an impure chalcocite. If found in such quantity that it can be obtained free from impurities it should be saved for chemical tests. Large bodies of iron oxide that result from the oxidation of iron sulphide may be expected, if they contain a trace of copper, to pass downward into pyritous ores, enriched by copper sulphide, and then into normal pyrite with a little copper sulphide.

21. Silver Deposits.—In silver-bearing ores the very rich silver minerals, such as horn silver and the native metal, occur in the oxidized zone. The rich sulphides, arsenides, and antimonides, with the mixed minerals polybasite, tetrahedrite, etc., in the sulphide zone are liable to be of secondary origin. This can be proved when they are the last deposit in vugs and cavities and are connected with water channels leading to the surface. Native silver may also occur in the sulphide zone as the result of secondary alteration.

22. Base-metal Deposits.—In the baser ores, where, as is not infrequently the case, there is a decided predominance of lead compounds in the upper portions and zinc and iron sulphides at lower levels, there is a suggestion of re-distribution since original deposition in virtue of the lesser solubility of the former. Gold, though readily insoluble, is attacked by ferric sulphate and precipitated when the latter assumes the ferrous condition. This, together with the fact that near the surface the soluble sulphates of the other metals are more

readily removed by surface waters, will probably account for the common decrease in value of gold ores from the surface downward.

ECONOMIC AND COMMERCIAL CONDITIONS.

23. Conditions of Persistence.—The geologist is generally expected to give some opinion as to the future of a mine or mining district. He must summarize the evidence gathered. Favoring conditions for persistence are (a) evidence of strong dynamic action, which would produce strong fissure-zones and abundant water-channels; (b) abundant igneous intrusions, and evidence of strong chemical action in the alteration of the rocks, and (c) a visible impregnation of the rock-masses in general with metallic minerals, even if of no commercial value. The most important is the actually proved existence of large bodies of valuable ore. As a rule, large bodies of low-grade ore will lead to more permanent industry than very rich ores.

24. Commercial Conditions.—The general commercial conditions should be also considered; the proximity to and accessibility of the region to railroad lines, and consequent approximate cost of bringing in supplies and machinery and taking out ores; the question of supply of water for generating power, or for reduction purposes; of timber for building and mining work; of fuel for steam, and, if need be, for smelting, must be considered. Copper ores and most lead and zinc ores involve smelting operations, hence in their case cheap transportation is more indispensable; whereas, gold ores can frequently be reduced on the spot by amalgamation, cyanidation, or chlorination, and this may often be carried on at a profit in relatively inaccessible districts. It must be borne in mind, however, that telluride and pyritous gold ores generally require preliminary roasting.

25. Historical Data.—Data should be obtained on the spot as to the history of discovery and development of a mining region, paying especial attention to facts which bear upon what might be called its economic evolution. Also, all trustworthy data that may be of use in estimating the aggregate production of the various metals mined.

NEW INCANDESCENT LAMPS

CONDENSED FROM "ENGINEERING NEWS"

During the past few months several new incandescent lamps have been put upon the market in commercially successful forms, whose light-producing efficiency is considerably higher than the forms in use for many years past. Some of these new lamps give three or four times as much light from a given amount of power as the old style carbon lamps.

It seems probable that these new lamps may bring about many radical changes in the electrical industry. That there are at least possibilities in the field every one will admit. If we can get four times the light for a given power we can also get the same light as at present for one-fourth the power. The new advance means, therefore, not only better and more liberal illumination, but an extension of electric lighting into fields where it has been hitherto deemed too expensive,

Efficiency of a Light.—The efficiency of the common form of carbon filament lamp is only a fraction of one per cent. That is, of all the energy applied ninety-nine and a fraction per cent. goes off as waste heat. This has been the incentive for all the investigation and experimenting of many years back. The present time seems to have brought almost simultaneously the culmination of several distinct efforts. It should be remembered, however, that these practical results are the outcome of years of patient laboratory investigation and experiment.

It is impossible to make a uniform and completely logical definition of the "efficiency" of an illuminant from physical data. Light, is, of course, the physiological action of certain radiations of energy. Such effects vary with individuals and with external conditions. Rays close to yellow arouse greater optical sensations than rays of either the violet or red ends of the spectrum. One candle power of red or violet light represents a source actually sending out more radiant energy,

other than heat, than one candle power of yellow or green.

In general, it may be said that a solid light source is more efficient, that it has less waste heat, the higher its working temperature. The reverse is true of luminescent vapors and gases.

Selective Radiation.—The efficiency of an incandescent solid body depends on still another phenomenon, though to a lesser degree than on temperature. This is called "selective radiation," and just what is meant by the term is best shown by approaching it in a roundabout way.

At a given temperature, the total energy radiated in all ways (that is as light, as heat and as chemical energy) is greater per unit area for an ideal dead black surface than for any other known surface. In general, it may be said that any substance capable of being raised to a temperature of 1,500° C. or over, raidates less total energy than would the ideal dead black body, at that same temperature. A greater percentage of the energy radiated by the former passes in such wave lengths as cause the sensation of light than in the case of the ideal black body. Therefore, any body, other than the ideal black one, is selective in its manner of radiation. It is also obvious that the dead black body is the least efficient light source.

The common carbon filament approaches the dead black body the nearest of any filament made. Hence it is least efficient as a radiator of light, and it was only its valuable mechanical properties that caused its adoption for incandescent lamps.

The new filaments are better than the old carbon filaments for two reasons. First, they can be worked at higher temperatures, which are maintained by a less expenditure of energy. Second, a greater percentage of the total radiant energy exists in such wave lengths as the eye is most sensitive to. This is shown in the comparison of color values given in Table I.

The question naturally arises as to why the old carbon filament cannot be worked, at these higher temperatures, since the melting and boiling point of carbon is so remote. It has been demonstrated that the highest temperature at which any filament can be operated with a reasonable economical life does not depend on the melting or boiling point of the substances from which the filament is formed, but upon its vapor tension or liability to gradual evaporation at lower temperatures.

The Metallized Carbon Filament Lamp.—The new form of carbon filament known as "metallized" owes its success as a light source to two properties. The first of these is a greatly lessened tendency toward evaporation of the filament or some content thereof. This consequently gives a much smaller amount of blackening of the interior walls of the bulb and enables the usual life of the lamp to be limited by the time of actual rupture of the filament. This increased vapor tension effect is due probably to an altered chemical composition of the filament itself. As will be shown later, the chemical composition of the filament is changed in two ways.

The second property, more or less related to the first, contributing to its value as an illuminant, is its increased strength, enabling operation at a much higher temperature and a consequent per unit of light furnished.

Up to a certain point both types of filament are made alike. Pure cotton is made into soluble cellulose, carefully heated and settled to remove air bubbles and to insure a proper degree of consistency. This solution is squirted into jars of alcohol by automatic machines and at the same time coiled as a continuous thread in the bottom of the liquid. This gelatinous thread receives a preliminary drying by passing around steel drums properly heated. The threads are redried on proper forms in ovens, and cut into individual lengths. The threads are packed in iron boxes with pulverized peat and subjected to the highest heat obtainable in an oven, without using an electric furnace. The carbonized filaments are measured, selected and assorted before receiving further attention.

From this point, the old and new processes are distinct. The filaments for the old style lamps are next "flashed," or raised to partial incandescence for a short space of time, in a rarified vapor of gasoline or other hydrocarbon.

The filaments for the metallizing process are packed with powdered carbon in an electric tube furnace and subjected to the highest heat possible with this type of furnace. So high is the temperature attained that the carbon tube in which the filaments are packed is so nearly destroyed that it cannot be used a second time.

After this metallizing process, the filaments are "flashed," as were the others, in a rarified atmosphere of hydrocarbon vapor. The carbon deposited on the filament by this portion of the process needs to be itself treat-

ed to a term in the tube furnace, after which the filament is reflashed in the gasoline vapor. It is now ready for assembling in the completed lamp.

It is believed by some persons that there is during the second heating in the tube furnace a polymerization of the atoms of that carbon which was deposited in the first flashing. The graphitic appearance and peculiar physical properties might be explained by such a theory of a polymeric arrangement of the atoms.

If this "allotropic" form of carbon, as some persons choose to call it, be deposited on such a core as may later be removed at desired stages of the process, most remarkable physical properties are manifested. At one stage, such a little tube could be pressed together, say by a hard blade, and when pressure is removed would spring into its original shape as though made of rubber. At a different stage of the process the tube would behave as one made of lead. These characteristics are foreign to the hitherto known physical properties of carbon.

The physical stability of the metallized filament is so much greater than the ordinary, that the allowable working temperature has been increased from 1,800° C. to 1,950°. For same candle-power units a filament of smaller cross-section is employed in the metallized type than in the ordinary.

The metallized lamps are made in 250, 187, 125, 100 and 50-watt sizes, all having a useful life of about 550 hrs., with a power consumption of 2.5 watts per c. p.

The Tungsten Filament Lamp.—Metallic tunsten is brittle, and infusible by ordinary commercial methods. It unites with both carbon and oxygen at high temperatures. The methods of filament manufacture seem numerous, and there may be possible several commercial and competing processes.

There are at least two American processes of making tungsten filaments, the exact stages of which cannot herein be stated. In general it may be said that the tungsten is held suspended in a finely divided state in such a solution as is squirted into filaments. The solution, of course, must contain enough binding material to allow the drying and welding processes to be carried on.

The tungsten filaments exhibit the usual characteristics of pure metals. The electrical conductivity is high, requiring a long filament of small cross section. The temperature-resistance coefficient is positive, and on this account the lamps have considerable inherent regulation. The changes in light production and power consumption are less for given voltage fluctuations than in the case of the older carbon filament lamps.

The color of the light emitted at proper voltage is near that of acetylene gas used in a good burner.

On account of the brittleness of tungsten trouble is found in shipping lamps with the

FIG. 1. THE AMERICAN-MADE TUNGSTEN 110-VOLT LAMP.

lighter and longer forms of filaments over American railroads. The loss by breakage may rise as high as 50 per cent.

The tungsten filament adapts itself to series street lighting systems which are favorably compared with any other illuminant in economy. This could not be said of the older form of carbon filament series lamps. The

FIG. 2. THE TANTALUM FILAMENT LAMP.

tungsten series lamps can be operated for about 1,000 hours life with a power consumption of 1.25 to 1.50 watts per c. p. They are sold in 40 and 60 c. p. units for 4.0, 5.5, 6.6 and 7.5 ampere systems.

The Tantalum Filament Lamp.—Pure tantalum is quite difficult to obtain, and only by an expensive process. It is known to have a tensile strength equal to that of the best steel and a melting point of about 2,300° C.

When the lamp is new, the filament appears as a fine and fairly smooth wire. Later the filament undergoes some structural changes. This effect may be regarded as a crystallization which becomes accentuated by using the lamp on alternating circuits, and it increases with higher frequencies. By use with direct current the crystals—if the action can be called crystallization—arrange themselves in a uniform order, while by reversals of the alternating current these crystals as formed arrange themselves irregularly. The appearance under the microscope is such as to give the impression that the filament had

repeatedly separated and immediately welded itself together again. This is shown in Fig. 5, reproduced from the "Proceedings of the American Institute of Electrical Engineers."

Welds do take place after the filament has visibly parted, and the joint apparently is as strong as the original wire.

These lamps are being made in this country in two sizes, a [illegible]-watt and a [illegible]-watt, for voltage of 100 to 125. The list prices are [illegible] to [illegible] cts., respectively. An average life of the lamp on direct current of 1,000 hours may be expected.

The Helion Filament Lamp.—While this type of filament is not strictly metallic, it has some characteristics which would be expected of the metals. For instance, the filament may be fused together by contact, much like a tantalum filament.

The Helion filament is composed to a great extent of silicon, which is at present deposited on a special carbon filament. Professor Parker has stated that he believes that the resultant form of silicon, from the "Helion" process may be regarded as "allotropic," bearing the same relations to amorphous silicon that the "metallized" form of carbon bears to the amorphous. Some physicists who have examined the Helion filament believe that the silicon is present as a carbide.

The name applied to the lamp was given because of the striking similarity of the spectrum of its light to sunlight. As was early observed, it gives off a white light at a temperature at which a carbon filament emitted only red rays. A larger portion of its light exists in those wave lengths to which the eye is most sensitive, than in the case of the carbon filament. These facts indicate that the "Helion" filament owes its high efficiency to selective radiation.

In experimental lamps so far made as low as [illegible] have been made for operation on [illegible] to [illegible] volts with an energy consumption of [illegible] watt per [illegible].

The [illegible] Filament Lamp.—[illegible] a crystalline [illegible] metal [illegible] that [illegible]. The [illegible] making [illegible] filament [illegible] is the same [illegible] those of the [illegible] of tungsten wires. The [illegible] watts [illegible]. This lamp is not [illegible] in the United States.

The Nernst Lamp.—The results of the experimental research of Dr. Walter Nernst, at the University of Göttingen, Germany, became commercially practical [illegible] in the [illegible].

Therefore this lamp can hardly be called a new one, but as it has, by the efforts of the Westinghouse interests, been installed in very many large offices and stores, some space should be given to it in this article. Moreover, there are new developments not yet announced.

The basis of Dr. Nernst's research was the fact that many substances which ordinarily are insulators, or at least very poor conductors, can conduct current fairly well at high temperatures. Among such substances may be mentioned lime, magnesia, glass and the rare earths, so-called. Their conduction of electricity is largely due to electrolysis.

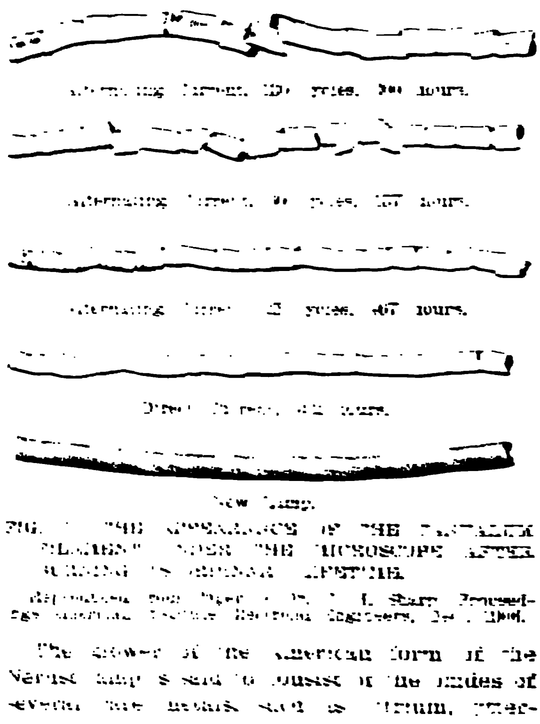


FIG. 5. THE APPEARANCE OF THE TANTALUM FILAMENT UNDER THE MICROSCOPE AFTER BURNING VARIOUS LENGTHS.

Reproduced from Paper by Dr. C. H. Sharp, Proceedings American Institute Electrical Engineers, Dec., 1906.

The glower of the American form of the Nernst lamp is said to consist of the oxides of several rare metals, such as thorium, yttrium, [illegible], although the true composition is known only to a few. The glowers are in the form of a short, thick filament, connected, at each end, with platinum terminals by which it is connected to low and those to leading [illegible] which are porcelain tubes in which are [illegible] resistance wires. These [illegible] necessary to bring the glower up to a temperature where [illegible] the [illegible] resistance [illegible] glower, which [illegible] electro-magnet [illegible] heater circuit. When the glower [illegible] heated to conduct, the current in this [illegible] its [illegible].

cuit operates the electro-magnetic switch and automatically cuts out the heating coils. On account of the large negative temperature-resistance coefficient of the glower, "ballast" is placed in the circuit. This consists of fine wire wound around a porcelain pencil and sealed in a glass tube to prevent oxidation at the high temperature reached. This iron wire has a large positive temperature-resistance coefficient which tends to balance the negative one of the glower, reducing the current fluctations in the latter, and increasing the steadiness of the light.

The mean lower hemispherical rating of the Nernst lamp is now about 1.3 watts per c. p. The average life of the glowers approaches 1,000 hrs., with very steady voltage and high frequency.

The color value of light from a Nernst glower is better than that of the common incandescent lamp, though the light is not so white as that of an enclosed or magnetite arc. On account of the great intrinsic brilliancy of the glower, lamps with clear globes are apt to have a dazzling effect, under ordinary circumstances.

TABLE I.—COLOR COMPARISON OF NEW LAMPS WITH COMMON CARBON FILAMENT (3.1 WATTS PER C. P.).

Color Screen.	Metallized 2.5 w. p. c.	Tantalum 2.0 w. p. c.	Tungsten 1.25 w. p. c.
Clear	100%	100%	100%
Red	96.7	92.7	87.5
Yellow (Crova)	100.1	100.8	99.5
Green	100.1	103.1	104.1
Blue	105.9	114.1	128.7

The values given in the table are expressed in terms of the "clear" value of the old form of filament. Thus in column 2, the relative candle power of the "metallized" lamp, in the red region of the spectrum, is 96.7% of that of the older type lamp in the same spectral region, indicating that the new form has a corresponding decrease in red rays.

TABLE II.—COMPARATIVE PERFORMANCE OF INCANDESCENT FILAMENT ELECTRIC LAMPS.

	Useful life.	Watts per c. p. New.	Watts per c. p. Old.	Cost.*
Common carbon	550	3.1 to 4	4 to 6	$0.16
Metallized carbon	550	2.5	2.6	0.20
Tungsten	1,000	1.25	1.3	1.35 & $1.50
Tantalum	1,000	2.0	2.2	0.45 & 0.60

*These are comparative list prices and are to be regarded as general and approximate.

HIGH-SPEED STEEL TOOLS

By E. R. NORRIS

CONDENSED FROM "THE ELECTRIC JOURNAL."

Mr. F. W. Taylor, president of the American Society of Mechanical Engineers, recently* read a paper before that body on "The Art of Cutting Metals," in which were described at length the results of investigations made by himself and others associated with him. Experiments extending over a period of many years had been carried out with the view of determining the proper heat treatment of cutting tools, their shapes, angles, feeds, cutting speeds, etc. During these experiments it was discovered that Mushet and other self-hardening tools, which had been previously looked upon as suitable only for cutting hard metals, could be used with even greater effect upon soft metals. This was followed by the discovery that by flowing water freely upon the chip and upon the nose of self-hardening tools, a much higher cutting speed could be employed. Still later it was found that tools made of chromium-tungsten steel, which had been heated close to the melting point during treatment, could be operated at even higher speeds and coarser feeds, thus giving a further advantage over other tools in the amount of work performed. Increased output is accompanied by a much higher temperature in the tool, and the ability to stand up to the work under these conditions may be said to be a characteristic of all high-speed tools. This discovery of the properties of chromium-tungsten steel directed the attention of other investigators to the subject, and their labors have resulted in the production of many similar varieties of high-speed tool steels.

Steels of this class may, with a few exceptions, be grouped as follows:

A—Carbon—chromium—tungsten.

B—Carbon—chromium—molybdenum.

*December (1906) meeting.

[illegible]—Carbon — Chromium — Molybdenum—Tungsten.

4—Carbon—Tungsten—Nickel.

Considerable variation exists in the composition of these steels, particularly in regard to the quantity of each of the principal elements entering into them.

As [illegible] recommended as the outcome of his [illegible] experiments:

	Per Cent.
Carbon	[illegible]
Manganese	[illegible]
Silicon	[illegible]
Phosphorus	———
Tungsten	[illegible]
Chromium	[illegible]
Sulphur	———
Vanadium	[illegible]

All of these elements perform certain useful functions with the exceptions of sulphur and phosphorus which are termed impurities and which should, therefore, be reduced to the lowest practical amount.

The forging and heat treatment (hardening and tempering) of high-speed steel tools while similar to the corresponding operations with carbon steel tools are, as found, less difficult on account of the impossibility of injuring them by heating to excessive temperatures.

As summarized by Mr. Taylor with reference to lathe or planer tools the process consists of two steps, the first a "high heat" treatment or hardening, the second a "low heat" treatment or tempering. In the high heat treatment the tool is:

(a) Heated slowly to [illegible]

(b) Heated rapidly from [illegible] to just below the melting point.

(c) Cooled rapidly to below [illegible]

(d) Cooled either rapidly or slowly from [illegible] to the temperature of the air.

In the second or low heat treatment the tool is:

(a) Heated to [illegible]

(b) Cooled either rapidly or slowly to the temperature of the air.

Heating [illegible] the melting point [illegible] hardness [illegible] in the sense that [illegible] hardness [illegible] of which a tool is enabled to retain whatever degree of hardness it originally possessed, even after working it in service up to a red heat. It is of the utmost importance never to permit a tool which is undergoing the high heat treatment to become re-heated during the first part of the cooling process, that is, between the limits of its melting point and its recalescent point, for it has been shown that tools chemically the same but subjected to such re-heating give totally unlike results in performance.

To assist in obtaining uniformity of temperature the molten lead bath mentioned as being used in the hardening of carbon steel tools is quite frequently employed in the cooling of high-speed steel tools from the high temperature to below the point of recalescence. The same bath is also used in the tempering or low heat treatment of the tools.

With the idea of still further extending the use of a molten bath so as to make it available for the hardening or high heat treatment of high-speed tools an electric furnace has been recently constructed in which molten copper forms the bath.

The Life of the Tool.—By the life of the tool is meant the length of time it can be kept working at maximum efficiency before regrinding becomes necessary. This is dependent upon—

1—The quality of the material to be cut.

2—The composition of the tool.

3—The hardening and tempering of the tool.

4—The shape of the tool.

5—The speed and feed.

6—The dimensions of the cut.

7—The cooling fluid.

Excepting the first two items and to a lesser extent the third, these several requirements can be met with reasonable exactness. It is almost impossible to determine in advance with any degree of refinement the quality of the material to be worked. For example, it may be gritty on the outside while internally soft and easy to cut, or it may be hard in portions, depending upon the mixing of the ingredients, their qualities and the temperatures of melting, pouring and annealing. Where this [illegible] these conditions making all [illegible] speeds and wear on the tool [illegible]. However a knowledge of [illegible] customs of foundry work, [illegible] analysis of the material, [illegible] to be drawn and used as a basis in ordinary commercial work.

Shape of the Tool.—In the design of a roughing tool for [illegible] work, so many opposing features require consideration that it may be said the resulting tool is a com-

promise affair, embodying no one idea to the exclusion of any other. This feature will be quite evident when some of the more important of these features are enumerated.

A tool with a perfectly straight cutting edge has a tendency to chatter; a round nose tool reduces this tendency and thereby produces a more evenly finished piece of work. A tool with a large radius to the nose may usually be run at a higher speed than one with a smaller radius, but the chip is thinner. Clearance is necessary between the tool and its work below the cutting edge; the greater this clearance, the more readily the tool cuts and the less the liability of the under portion riding against the work; on the other hand, the greater the clearance, the weaker the nose of the tool becomes, with the consequent increasing danger of its crumbling away. A tool should always have back slope as well as side slope; that is, a downward slope on the top away from the cutting edge as well as to one side. Like clearance, back slope and side slope both weaken the nose of the tool; but, while back slope piles the chip against the tool post, side slope turns it to one side; the real purpose, however, of both side and back slope is to give the proper clearance to the cutting edge of the tool and thus to reduce the tendency of its being pushed away from the work.

Experience has demonstrated that for all-around work, either on hard material or on soft, in the smallest lathe or on the largest boring mill or planer, the round nose tool is best. Regardless of size or class of work, the contour of the nose is about the same, but the angles of the edges as well as the bluntness of the nose vary.

Mr. Taylor recommends a clearance of six degrees and a back slope of eight degrees for all sizes of tools. The side slope, however, changes, being fourteen degrees in the case of tools for cutting hard steel and cast iron, and twenty-two degrees for cutting medium and soft steel. The radius of the nose is derived from the formula—

$R = 1/2A—5/32$ in. for blunt tools;

$R = 1/2A—3/16$ in. for sharp tools;

where R = radius of point and A = width of tool.

Applications of High-speed Tools.—High-speed steel tools, as their name implies, are capable of being operated at considerably higher speeds and feeds than cutting tools made from the ordinary carbon steels. Their advent into commercial work compelled machine tool builders to re-design their products so as to make them suitable for these higher speeds and feeds with their attendant increased strains, etc. Manufacturers, even though they recognized the merits of high-speed cutting tools, could not, for obvious reasons, discard all of their machine tools which were not strictly adapted to the new order of things. Before them, therefore, was placed the perplexing problem as to what extent their machine tools could be used advantageously with the high-speed cutting tools or to what extent their machine tools should be altered or replaced.

From this it will be seen that in commercial manufacturing as it exists to-day, there are of necessity two standards of maximum speeds and feeds, depending upon whether one refers to the machine tool or to the cutting tool.

Considering a particular machine tool, the maximum speed and feed at which it should be worked in connection with a certain class of material can be found only by actual trial. When making such an investigation, all of the factors entering into its operation should be taken into account at the very outset and but one of them changed at a time, the others remaining constant. It is of the utmost importance, too, that these factors be prime and not composite. A few years ago elaborate tests on high-speed steels were made at the Manchester (England) School of Technology. Mr. Taylor, in commenting on these tests, points out that the value of some of the data then obtained is very much detracted from, because the area of the cut was taken as a single factor, the assumption being made that the effect of depth times width was always the same, whereas the width of feed has a greater influence than the depth upon the cutting speed.

As showing the speeds and feeds practically attainable on the basis of the cutting tool being worked for one hour and thirty minutes without regrinding, the two following tables, reproducing in part data compiled by Mr. Taylor, will prove of interest. The tool used was a one-inch round nose tool of approved design and composition.

Both iron and steel contain carbon in its two states, combined and graphitic, though the total amount of carbon is usually much greater in iron than in steel. It is a well known fact that as the percentage of combined carbon increases the metal becomes harder, and while this may therefore account in part for the difference in cutting speeds between soft, medium and hard iron or be-

TABLE I.—SHOWING THE SPEEDS AND FEEDS PRACTICALLY ATTAINABLE WITH HIGH-SPEED TOOLS OF APPROVED DESIGN WORKING ON CAST IRON AND STEEL WITHOUT ... (TAYLOR).

Depth of Cut in Inches	Feed in Inches	Cast Iron Soft	Cast Iron Medium	Cast Iron Hard	Steel Soft	Steel Medium	Steel Hard
		Cutting Speed in Feet per Minute					
[illegible]	[illegible]	[illegible]	[illegible]	40.1	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	56.4	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	307	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]			
	[illegible]	[illegible]	[illegible]	[illegible]			
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]			
	[illegible]	[illegible]	[illegible]	[illegible]			
	[illegible]	[illegible]	[illegible]	[illegible]			

tween soft, medium and hard steel. It does not explain why the cutting speeds for steel should be higher than the cutting speeds for the corresponding grades of cast iron. Mr. Taylor offers as a possible solution, though with some hesitation, a very ingenious theory. Cast iron when compared with steel is practically without stretch. This absence of stretch or ductility of the metal at first causes the entire pressure of the chip to concentrate upon the tip of the tool close to the cutting edge, thus tending to heat it excessively. In steel the stretch is very considerable, thereby enabling the metal to flow or spread itself out in a thicker chip over the lip of the tool, the thickness of the chip depending upon the relative softness of the metal. As a result the pressure per unit area upon the lip surface of the cutting tool in contact with the metal, as well as the consequent heating effect, is probably as great with cast iron as with steel. Again, graphitic carbon is present in cast iron to a greater or lesser degree, while in steel it is almost nil. This material acts as an abrasive, thus in-

TABLE II.—SHOWING HOW PRESSURE OF CHIP ON TOOL AND ALLOWABLE CUTTING SPEED ARE AFFECTED BY THE KIND AND QUALITY OF THE METAL BEING WORKED (TAYLOR). DEPTH OF CUT = [illegible] INCH, FEED [illegible] INCH.

	Kind of metal	Total per cent of carbon	Per cent of combined carbon	Pressure of chip on tool in tons per square inch sectional area of cut	Per cent of stretch	Cutting speed in feet per minute
Cast Iron	Soft	[illegible]	[illegible]	[illegible]	....	140
	Medium	[illegible]	[illegible]	[illegible]	....	49
	Hard	[illegible]	[illegible]	[illegible]	..	32
Steel Forging	Soft	[illegible]	....	[illegible]	[illegible]	111
	Medium	[illegible]	..	[illegible]	[illegible]	80
	Hard	[illegible]	.	[illegible]	[illegible]	41

creasing still more the wear of the tool. These various points are well brought out in the preceding Table II, as is the further point that no direct proportion exists between the cutting speeds and the pressures on the tool.

No one thing has done more to give an impetus to the use of high-speed steel cutting tools than the variable speed motor. In the average machine tool equipped with belt drive the changes of speed are usually quite limited and frequently either the nature of the work or the trouble involved in changing from one speed to another prevents the workman from taking advantage of them. Through the medium of the variable speed motor maximum cutting speeds can be obtained regardless of the diameter of the work or of the number of times the diameter changes in the course of a single cut.

Several advantages are derived from the use of a copious stream of soda water or oil properly directed upon the nose of the tool: the cutting speed is increased from 33 to 40 per cent, the power required for driving is reduced from 5 to 15 per cent and the finish of the work is of a higher grade, though this last is not ordinarily of great importance in roughing work.

THE MODERN AMERICAN BLAST FURNACE

By BRADLEY STOUGHTON*

SLIGHTLY CONDENSED FROM ARTICLES IN "THE ENGINEERING AND MINING JOURNAL"

In the modern blast furnace, according to American practice, much attention has been paid to the various devices for handling the material and charging the furnace. The object has been to save time, to keep the furnace working to full capacity, and to dispense with manual labor as far as possible.

Handling the Raw Material.—Behind the blast furnace are situated two long rows of storage bins. These bins are filled by bottom-dumping railroad cars, which bring the ore to the furnaces, or by mechanical apparatus from the great piles of ore stored conveniently near. Between and under these two rows of bins runs a track on which little trains of ore buggies are transferred back and forth, being first filled with a weighed amount of ore, limestone or fuel, and then switched into a position where they can deposit their contents into the loading skip of the blast furnace.

Loading the Furnace.—In one of the big modern American furnaces, working at top speed, the amount of material which must be dumped into the top during 24 hours will frequently exceed 2,000 tons, and the charging must go on for 365 days a year with never a delay of more than a few hours at a time.

In the modern type of furnace this loading is accomplished altogether by mechanism operated and controlled from the ground level, and no men are required to work at the top of the furnace. A double, inclined skipway extends above the top of the furnace. One skip discharges its load of ore, fuel or flux, into the hopper, while the second skip is at the bottom of the incline ready to be loaded with its charge.

The upper hopper of the furnace is closed at the bottom by an iron cone, known as a "bell." This bell is pressed up against the bottom of the hopper by the lever of the counterweight, but may be lowered by operating the cylinder shown at the side to allow the charge to fall into the true hopper of the blast furnace. In this way the true hopper of the furnace is progressively filled with ore, flux and fuel. This hopper is also closed at the bottom by a similar bell. The lowering of this bell is also controlled by mechanism operated from the ground level. At intervals this operation is effected, and the content of the hopper allowed to fall in an annular stream, distributing itself in a regular layer on top of the material already in the furnace and reaching to within a few feet of the bottom of the bell. As the upper bell is now held up against the bottom of the upper hopper, there is never a direct opening from the interior of the blast furnace to the outer air, so that the escape of gas, resulting formerly in the long flame rising from the top of the blast furnace whenever material was dropped into the interior, no longer occurs at our modern plants.

This is not the only means of handling the raw material for the blast furnace, but the description given heretofore is illustrative of the general principles of labor-saving handling in connection with charging the blast furnace.

The Blast Furnace and Accessories.—The blast furnace itself consists of a tall cylindrical stack lined with an acid (silicious) refractory firebrick. The hearth or crucible is the straight portion occupying the lower 8 ft. of the furnace. Above that extends the widening portion, called the bosh, which reaches to that portion of the furnace having the greatest diameter. The stack extends throughout the remainder of the furnace, from the bosh to the throat. The brickwork of the hearth is cooled by causing water to trickle over the outside surface.

Tuyeres.—Through the lining of the furnace, just at the top of the hearth, extend the tuyeres—eight to sixteen pipes having an internal diameter of 4 to 7 ins., through which hot blast is supplied. The "tuyere notches," or openings through which the tuyere pipes

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enter, as well as the tuyeres themselves, are surrounded by hollow bronze rings set in the brickwork, through which cold water is constantly flowing to protect them from being melted off at the inner ends. The number and size of the tuyeres are regulated in proportion to the diameter of the hearth, the volume and pressure of the blast, etc., so that the velocity of the blast shall distribute it as evenly as possible to the very center of the furnace.

Discharge Holes.—On the side of the furnace, and 30 to 40 ins. below the level of the tuyeres, the "cinder notch" or "monkey" is situated. This is protected by a water-cooled casting, and the hole is closed by an iron plug, or bott. In the front, or breast, at the very bottom level of the crucible is the iron taphole, from which all the liquid contents of the furnace can be completely drained. This is a large hole in the brickwork, and is closed with several balls of clay.

The Bosh.—The hottest part of the furnace is near the tuyeres and for a few feet above them. In order to protect the brick work of the bosh from this heat a number of hollow wedge-shaped castings are placed therein, through which cold water circulates. The brickwork is furthermore protected by a deposition of a layer of carbon, similar to lamp black, on its internal surface, covered by a layer of a sort of slag, replacing part of the brickwork. This deposition of carbon comes about through the reaction of the furnace operation itself. For the correct conduct of the smelter operation, and especially for the carrying off of the sulphur in the slag, it is necessary that a very powerful reduction influence must exist; this reducing influence is produced by an excess of coke and one of its results is the precipitation of finely divided carbon on the internal walls of the furnace. It is this thin layer of slag and carbon which is most effective in protecting the acid lining of the furnace from the corrosive action of the basic slag.

The air for smelting is driven into the furnace by blowing engines up to 2,500 HP. each, and capable of compressing 50,000 to 65,000 cu. ft. (4,875 lbs.) of free air per minute to a pressure of 15 to 30 lbs. per sq. in., which is about what one furnace requires. It actually requires about four to five tons of air for each ton of iron produced in the furnace. After leaving the engines and before coming to the furnace the air is heated to a temperature of 800 to 1,200° F. by being made to pass through the hot-blast stoves.

Hot Blast Stoves.—Each furnace is connected with four stoves. These are cylindrical tanks of steel about 110 ft. high and 22 ft. in diameter, containing two firebrick chambers. One of these chambers is open and the other is filled with a number of small flues. Gas and air are received in the bottom of the open chamber, in which they burn and rise. They then pass downward through the several flues, in the annular chamber surrounding the open chamber, and at the bottom pass out to the chimney as waste products. In passing through the stove they give up the greater part of their heat to the brickwork. After this phase is ended the stove is ready to heat the blast. The blast from the blowing engine enters at the bottom of the flues, passes up through the outer chamber, down through the central chamber and to the furnace. In this passage it takes up the heat left in the brickwork by the burning gas and air. Sometimes there are three passes, instead of two, as described. In a blast-furnace plant one stove is heating the blast while the other three are simultaneously in the preparation stage, burning gas and air. By changing once an hour a pretty regular blast temperature is maintained. The gas used for the heating is the waste gas from the blast furnace itself, which amounts to about 90,000 cu. ft. per minute at a temperature of 450° F., and has a calorific power of about 85 to 95 B. T. U. per cu. ft. The latent and available heat of this gas is equivalent to approximately 50% of that of the fuel charged into the furnace. Only about 30,000 cu. ft., or one-third of this gas, is needed for keeping the stoves hot and the remaining two-thirds is used to produce power. If the stoves become clogged with dust, a larger amount of gas is required to keep up the temperature.

Power from Waste Gas.—The waste gas comes down the down-comer, settles out dirt in the dust-catcher, and is then led to the stoves or the power producer. This gas varies in composition, but will average about 61% nitrogen, 10% to 17% CO_2 and 22% to 27% CO. The latter can be burned with air to produce heat. If burned under boilers, the available gas will generate enough power to operate the blowing engines, hoisting mechanism, and other machinery used in connection with the furnace. At several plants the gas available for power is cleaned carefully and utilized in gas engines, whereby much more power is obtained, the excess over that necessary to furnish blast and the mechanical requirements of the furnace being usually converted into

electricity and transmitted to more distant points.

Smelting Practice and Products.—The furnace is filled with alternate layers of fuel, flux and ore, down to the top of the smelting zone. The exact location of this zone will be dependent upon the volume and pressure of blast, size of furnace, character of slag made, etc., but will extend from the level of the tuyeres to a few feet above them; that is, about to the top of the bosh. It will require perhaps 15 hours for the material to descend from the top of the furnace to the smelting zone. During this descent, it is upheld partly by the resistance of the upward rushing column of hot gases, partly by its friction against the walls of the furnace, and partly by the loose column of coke which extends through the smelting zone and to the bottom of the furnace and which alone resists melting in the intense heat of this zone. The blast, entering the furnace through the tuyeres, consists of 23% by weight of oxygen, 77% by weight of nitrogen, together with varying amounts of water vapor from moisture in the air.

CHEMICAL REACTIONS.

Upper Levels.—As soon as the iron ore enters the top of the furnace, two reactions begin to take place between it and the ascending gases:

(1) $2Fe_2O_3 + 8CO = 7CO_2 + 4Fe + C.$

(2) $2Fe_2O_3 + CO = 2FeO + Fe_2O_3 + CO_2.$

These reactions continue with increasing rapidity as the material becomes hotter. The carbon formed by reaction (1) deposits in a form similar to lamp-black on the outside and in the interstices of the ore. This reaction is, however, opposed by two reactions with carbon dioxide gas:

(3) $Fe + CO_2 = FeO + CO;$

(4) $C + CO_2 = 2CO.$

Reaction (3) begins at a temperature of about 575° F. which is met with about 3 or 4 ft. below the top level of the stock, and (4) begins at about 1,000° F., or 20 ft. below the stock line. Reaction (4) is so rapid that the deposition of carbon ceases at a temperature of 1,100°.

All the way down the ore is constantly losing a proportion of its oxygen to the gases. At higher temperatures than 1,100° F., FeO is stable and practically all of the Fe_2O_3, (or Fe_3O_4 if magnetite is being smelted), has been reduced. At 1,300° F. solid carbon begins to reduce FeO. Practically all the iron is reduced to a spongy metallic form by the time the temperature of 1,475° is reached. This is about 45 ft. from the stock line and less than 30 ft. above the tuyeres. At 1,475° F. the limestone begins to be decomposed by the heat, and only CaO comes to the smelting zone. It is not supposed that these figures are exactly correct for the different levels, and it is probable that they change from day to day and from furnace to furnace. It will be seen that the upper 15 or 20 ft. of the stock is a region of Fe_2O_3 and Fe_3O_4, gradually being converted to FeO by CO gas, and forming quantities of CO_2 gas. If these reactions are the only ones, the top gases would contain no CO, and have no calorific power, but reaction (1) produces both metallic iron and carbon, both of which reduce CO_2 and waste much energy as far as the blast furnace is concerned. Thus (3) $Fe + CO_2 = FeO + CO$, absorbs 2,340 calories, but wastes 68,040 calories, while (4) $C + CO_2 = 2CO$, absorbs 38,880 calories.

From 20 to 35 ft. below the stock line is the region of FeO, gradually being converted to metallic iron sponge by carbon. On the lower level of this zone the limestone loses its CO_2 which joins the other furnace gases. From 35 ft. down to the smelting zone is the region of metallic iron. This spongy iron is impregnated with deposited carbon which probably to some extent soaks into it and dissolves, in a manner like in nature, but not in degree, to the way ink soaks into blotting paper. This carburization of the iron reduces its melting point and causes it to become liquid at a higher point above the tuyeres than it otherwise would.

On reaching the smelting zone the iron melts and trickles quickly down over the column of coke, from which it completes its saturation with carbon. At a corresponding point the lime unites with the coke ash and impurities in the iron ore, forming a fusible slag which also trickles down and collects in the hearth. It is during this transit that the different impurities are reduced by the carbon, and the extent of this reduction determines the characteristics of the pig iron, for in this operation, as in all smelting, reduced elements are dissolved by the metal while those in the oxidized form are dissolved by the slag. Only one exception occurs; namely, that iron will dissolve its own sulphide, FeS, and, to a less extent, that of manganese, MnS, but not that of other metals as, for instance, CaS.

Smelting Zone.—There is always a large amount of silica present in the coke ash and

some of this is reduced according to the reaction:

$$SiO_2 + 2C = Si + 2CO.$$

The extent of this reaction will depend on the length of time the iron takes to drop through the smelting zone, the relative intensity of the reducing influence and the avidity with which the slag takes up silica. A slag with a high melting point will trickle sluggishly through the smelting zone, and cause the iron to do the same to some extent, thus giving it more chance to take up silicon. A higher temperature in the smelting zone, which increases disproportionately the avidity of carbon for oxygen, will promote the reduction of silica. We can produce this higher temperature by supplying hotter blast. A larger proportion of coke to burden will further promote this reaction, because this not only increases the amount of the reducing agent, but also raises the temperature, and therefore the chemical activity of this agent. Thus the coke has both a physical and a chemical influence in increasing the intensity of the reduction in the smelting zone. A basic slag, because of its avidity for silica, will oppose the reduction of silica, and is one of the principal means of making low silicon pig iron. This is in spite of the fact that the basic slags are sluggish, and therefore trickle slowly through the smelting zone, thus exposing the silica longer to reducing influence, and also increasing the temperature of the materials in this zone (1) by causing them to pass through it more slowly and absorb more heat, and (2) by reducing the level of the smelting zone nearly to the tuyeres, which confines the intense temperature to the smaller area, or, in other words, diminishes the passage of heat upward.

Sulphur comes into the furnace chiefly in the coke. It is partly in the form of iron mono-sulphide, FeS, and partly in the form of iron pyrites, FeS_2, which loses one atom of sulphur near the top of the stack and becomes FeS, which will dissolve in the iron unless converted to sulphide of calcium, CaS. This is brought about according to the explanation of Prof. Howe by the following reaction:

$$FeS + CaO + C = CaS + Fe + CO.$$

The CaS passes into the slag and the elimination of sulphur is very strong when the slag is running from the furnace. It is evident from this reaction that intense reduction, which increases the silicon in the iron, has the contrary effect on the sulphur and this explains the common observation that iron high in silicon is liable to be low in sulphur. Indeed this relation is so constant as almost to be a rule. There are two exceptions, however: (1) Increasing the proportion of coke has a doubly strong influence in putting silicon in the iron; as regards sulphur, on the other hand, it has a self-contradictory effect: by increasing the amount of sulphur in the charge it tends to increase it in the iron, which is partly or wholly counteracted by its effect in the above reaction. (2) A basic slag may hold silicon from the iron, and it also holds sulphur from the iron by dissolving CaS more readily. In other respects the conditions which make for high silicon make also for low sulphur. Particularly is this true of a high temperature in the smelting zone, and the term "hot iron" has come to be synonymous in the minds of blast-furnace foremen with iron high in silicon and low in sulphur.

Manganese is reduced by the following reaction:

$$MnO + 2C = Mn + 2CO.$$

The amount of manganese in the iron is dependent, to a certain extent, upon the character of the ores charged, but it may be controlled somewhat by the character of slag made, because an acid slag will carry a large amount of manganese away in the form of silicate of manganese, $MnSiO_3$.

With a certain unimportant qualification, the amount of phosphorus in the iron is controlled by the character of the ores charged, and districts or countries having high-phosphorus ores must make high-phosphorus irons. This is not an insuperable objection, because the presence of phosphorus, even up to 1.5%, is desired in certain irons for foundry use, and the basic processes for making steel can remove this element.

The chemical influence of the blast furnace is a strongly reducing one and this is produced in order first to reduce the iron from the ore, second to get rid of the sulphur, and third to saturate the iron with carbon. Many attempts have been made to provide a process wherein the reducing influence was not so strong and thus to produce a purer material than pig iron, because it is the intensity of the reduction which vitiates the iron with carbon and silicon. The great weakness of all such processes, however, is that they do not get rid of the sulphur which is the most objectionable impurity that iron is liable to contain and which is not satisfactorily removed by any process after once it makes

its way into the iron. Finally, to saturate the iron with carbon renders the blast-furnace operation very much cheaper, because pure iron melts at a temperature much higher than can readily be obtained in the furnace and melted iron is handled much more cheaply than it could be if allowed to solidify. Even the presence of silicon is an advantage.

SOLAR ENERGY AND TEMPERATURE

FROM THE "ELECTRICAL WORLD"

In the last number of the "Physical Review" Mr. W. W. Coblentz contributes an article upon solar radiation, which sums up what has recently been ascertained concerning the probable temperature of the sun and moon. It appears that the radiation power of the sun, at the surface of the earth, amounts to about 1.75 KW. per square meter of perpendicularly exposed earth-surface. Of this, the books tell us about one-quarter is absorbed in the air, when the sun is at its zenith, or getting in his best work; so that what reaches the earth when the sun is overhead is, say, about 1.3 KW. per square meter. In the temperate zones, where the sun is never vertically overhead, the layer of air passed through by the sun's rays is thicker and the absorption consequently greater, especially in early morning and late evening, so that a square meter of surface kept facing the sun all day long during a clear summer day might only receive an average radiation power of about 0.5 KW. Of course, the square meter would reflect away a large proportion of this power, if its surface were of polished metal, and even a dull black surface, like that of plumbago, would dissipate convectively the heat which it received, so that it is very hard to catch and utilize this radiated solar power. Nevertheless, if we could employ this power practically and conveniently, we should obtain an immense benefit. Thus, allowing that the noonday solar power on a bright day was 1 KW. per square meter of perpendicularly exposed surface, we should only have to expose a surface of 10 meters square in order to receive 100 KW., and if an efficiency of 50% were imagined in the apparatus, we would be able to develop 50 KW. during the brightest part of the day from a disk about 37 ft. in diameter.

The only solar engine which has yet been made successful is the waterfall. A fraction of the solar radiation energy reaching the surface of the earth is expended in converting surface ocean-water into steam or water-vapor and in raising that steam to an elevation among the clouds. Part of this energy is released in rainfall, and only an insignificently small fraction of the rainfall occurs on elevated land in such a manner that a waterfall can be made available. There is at least one other type of solar engine possible, and that is a surface of chemical substance exposed to solar radiation and capable of being chemically transformed to a stable substance which will subsequently give up its energy for consumption. A grass meadow supporting horses is a crude form of such a machine. A small fraction of the incident solar energy is usefully absorbed by the chlorophyll in the grasses, permitting them to build up a hydrocarbon structure from an environment of gaseous water and carbon-dioxide. The horses consume and assimilate the grass, and each is capable of delivering a few kilowatt-hours a day of solar energy—an infinitesimal fraction of the total solar energy incident on the meadow. It might be possible to find a chemical substance much superior to chlorophyll as a recipient or storage material, and capable of releasing its energy in an electrical way. The paper shows that the surface temperature of the sun works out about 5,980° absolute of 5,707° C., each square meter of solar surface liberating apparently 67,600 KW. or not far from 100,000 HP. The effective temperature of the moon on the side facing the sun appears to be about 82° C. This shows how small a share of incident radiation energy a reflector can claim as commission for its duty. The moon is supposed to have little else to do, from a human utility standpoint, than to reflect radiation. She constantly receives a large total amount of radiation power, but is not able to raise her surface temperature thereby beyond about 100° C.

ALUMINUM COILS*

By FELIX SINGER

A new electrical invention has been recently patented in England, which, owing to its technical and material advantages, may become of considerable importance to the electrical industry.

The well known property of aluminum to become covered with a layer of oxide, even at ordinary temperatures, which, although hardly noticeable, offers such a resistance to the electric current that a potential difference of about 0.5 volt is required in order to break it down, is being utilized (in accordance with the above mentioned patent of a German electrician, Mr. Hubert Hopfelt) for winding magnet coils, solenoids, etc., with bare aluminum wire, the turns of which touch each other in the same manner as if the wire were specially insulated. It is clear that only the single layers of such a coil need to be insulated from each other by intermediate layers, as the potential difference between the same is greater than that between adjacent turns.

Theoretical and practical tests, made by prominent authorities, have fully proved, amongst other things, the advantages claimed for this invention, viz.:

1. An economy in cost of 40 to 50% as compared with insulated copper wires at high [illegible]

[illegible]

aluminum wire increases constantly during use, has proved unfounded. On the contrary, Mr. J. Parke, reading a paper some months ago before the "Canadian Electrical Society," stated that according to American experience the durability of an overhead line of aluminum wires was greater than that of one of copper wires.

Owing to the low conductivity of aluminum (which bears a ratio to that of copper wire of 1:1.7), the question as to the space required in using aluminum wire is of the greatest importance, especially for the construction of electrical machines. Calculations made in this direction have shown that aluminum wire up to a diameter of 1.3—1.5 mm. does not require a greater space than round copper wire covered with a double layer of silk or cotton, in spite of its greater volume.

When calculating aluminum coils, it is also to be noted that the temperature coefficient of resistance of aluminum is only 0.36, i. e., about 10% less than that of copper wire. Besides, aluminum coils will cool down better than coils of insulated copper wire. Many tests have shown that, in order to attain the same temperature, an aluminum coil can stand an overload of about 20% more than a copper wire coil of the same capacity. Considering these facts when calculating aluminum coils, the conductivity as compared with that of [illegible] be taken at 1:1.5.

[illegible] of the aluminum coils, to[illegible] the incombustibility of the insu[illegible] also produce an altera[illegible] for dynamos, motors, [illegible] temperatures will be per[illegible] wire.

[illegible] the aluminum [illegible] coils mount[illegible] the usual manner, [illegible] intermediate lay[illegible] single layers not [illegible] of hygroscopic [illegible] hard [illegible] small thickness [illegible] especially noted [illegible] passage of cur[illegible] the intermed[illegible] millimeters wider [illegible] overlap

the end windings by 1 or 2 mm. on each side. It has been shown that the layer of oxide, forming the insulation of the wire (aluminum oxide being nothing else than argillaceous earth, i. e., the raw material of porcelain) is increased by the action of dampness upon the coil in such a manner that several hundred volts are sometimes required in order to break down the insulating layer. It appears from this that coils used in the open air, such as field coils for electric railway or crane motors, coils of field telegraphs, electric bells, etc., are not affected by the dampness of the air or soil, if made from bare aluminum wire, but that such coils will, on the contrary, improve the more they are exposed to dampness.

It has hitherto proved to be a difficult process to solder aluminum wire, so that for each coil a single wire has had to be used. The inventor has succeeded in devising a simple and safe soldering (welding) process for aluminum wires, in which a direct union of aluminum with aluminum will be made (autogenous-welding.) No special apparatus are necessary for the use of this process; only a burner flame of acetylene, coal, spirit, or oxygen gas, and a fluid for the purpose of dissolving the oxide coating, that is, for the reduction of the alumina, are required.

The invention is the property of a German company (Syndicate for Aluminum Coils, Ltd., of Berlin), which is exploiting the invention only by granting licenses for the use of the patent rights in the various countries.

WHITE CEMENT *

Numerous experiments have been conducted, especially during the past three or four years, both on this continent and in Europe, in connection with the manufacture of white cement. The reason for this is that, in spite of the common Portland cement being an excellent building material for coarser work, such as foundations, sidewalks, etc., it is, on account of its dull gray color, of less avail for artistic work. The cementing material required for this purpose must be pure white and weatherproof, and need not have, as a rule, the strength of Portland cement. Plaster of Paris and magnesia cements have been used to some extent, but the former is not weatherproof, and the latter are not very reliable.

The coloring matter in Portland cement is oxide of iron, and sometimes oxide of manganese. To obtain a white color, the product should not have more than 0.80 per cent. Fe_2O_3. With this limitation there are some difficulties. It is not an easy matter to find suitable raw materials. Even if the limestone is easy to locate, the clay, which must be china clay, is scarce, and when found is likely to be rather expensive. Then, again, a mixture low in Fe_2O_3 requires very high heat, and is, therefore, hard to burn.

Some of the experimenters have tried to make white Portland cement, and others to make white Roman cement. Both have succeeded. There are now factories for white Portland cement in the United States and Germany. The following analysis is of a sample from Stettin, Germany:

SiO_2	19.82%
Al_2O_3	11.49%
Fe_2O_3	0.67%
CaO	61.60%
MgO	0.72%
SO_3	1.99%

The cement was sound, but was ground rather coarse. Mr. Julius Gresley, president of the Liesberg cement mill, Switzerland, has analyzed the best French Roman cements, and from these analyses he figures the following standard formula for his cement:

$$x\ [2\ (CaO.\ MgO).\ SiO_2] + y[2CaO.\ Al_2O_3] + z\ [CaO.\ SO_3]$$

The CaO SO_3 is not necessary, but seems to make the mixture burn easier. This cement comes on the market under the name of "Marbrit."

The following analysis shows the proportions of this product:

Moisture	3.75%
SiO_2	17.66%
Al_2O_3	16.52%
Fe_2O_3	0.74%
CaO	54.69%
MgO	0.53%
SO_3	6.11%

Specific gravity = 2.815.

The cement is sound, and ground fine, but is quick setting. Any kind of work will be hardened enough to release from its mould in two hours, or even sooner.

This cement possesses an advantage over the white Portland cement in that when it is strong enough for the purpose required it is easier to burn and cheaper to manufacture.

*A. G. Larsson, C. E., in the "Canadian Cement and Concrete Review."

NOTES ON SCIENCE AND ENGINEERING

FROM ALL SOURCES

Boron Steel contains boron in the form of an iron borocarbide. This borocarbide, which renders the steel very brittle, passes into solution when the metal is tempered at 850° C., provided that the boron content is low, but a portion remains undissolved when the amount of this element present is around 0.8%.

Adhesion Between Concrete and Steel.—Tests recently made in Germany by Dr. O. Meyer, and reported in the "Oesterr. Wochenschrift fuer den Oeffentlichen Baudienst," show that the average slipping resistance between steel bars (with the skin as it comes from the rolling mill) and concrete is about 650 lbs. per sq. in. of surface. The average resistance for turned or otherwise smoothed bars is about 235 lbs. per sq. in.

Formula for Calculating the Calorific Value of Fuels.—According to M. Lenoble, a simplified form of Goutal's formula which gives sufficiently reliable rough working results is: $P = 87.4\ (100-k)$, where P is the calorific value in kilogram-calories, and k is the sum of the percentages of moisture and ash, the latter being based upon the dry coal. The formula should not be used for coals of over 8,500 kg.-cals.

New Mercury Vapor Lamp.—A new mercury vapor lamp has been invented by Dr. Aron, of Berlin, and is being put out by the Allgemeine Electrizitaets Gesellschaft, of that city. This lamp differs chiefly from others of its kind in that the tube is fixed in a vertical position instead of being horizontally inclined, and that it can be worked with direct current. As it is self-lighting, it is not necessary to place it in a readily accessible position in order that it may be reversed for lighting purposes.

High Temperatures.—Experiments with the optical pyrometer recently made are of interest as indicating the temperatures that are reached in certain operations and in the sun. These results are as follows:

Porcelain furnace	2,498° F.
Glass furnace	2,552° F.
Open-hearth steel	2,795° F.
Melted platinum	3,236° F.
Incandescent lamp	3,272° F.
Arc lamp	7,410° F.
The sun	13,712° F.

—"American Machinist."

Operating Mechanisms from a Distance.—Professor Branly, an eminent French scientist, has devised a system for operating mechanical devices from a distant point, consisting of a wave-producer at the sending station, and at the receiving end a coherer and relay, a distributing device for operating the different apparatus under control, and an indicator or checking device which automatically sends signals to the operator. By means of this system it is possible to start a steam engine, start or stop a train, steer airships, submarine boats and torpedoes, from a distant station simply by operating a key.

Snow-Load on Roofs is the subject of some recent measurements by Mr. S. de Perrot, of Neuenburg, Switzerland. Where a heavy fall of snow was followed by thawing and freezing successively and then more snow, and thus in repeated cycle, a coherent laminar mass of snow and ice is formed on roofs, which is of remarkable density. Several such "snow" accumulations proved to have a weight of 36 to 38 lbs. per cubic foot. In these cases the thickness of the accumulated snow on the roof was 24 to 32 ins., thus producing a load of 70 to 100 lbs. per square foot. This is three or four times as much as is commonly assumed in calculation.—"Mechanical World."

Decomposition of Cement by Sea-Water.—According to M. Chatelier, all hydraulic binding agents, without exception, are capable of being decomposed by sea-water, but the rate

is action varies within wide limits. It ies relatively slow when alumina is presnly in small proportions. The addition zzuolana, especially of calcined clay and iss of good quality, endows all hydraulic its with considerably increased powers of ance to the action of sea-water. The essential condition to render cements ne from decomposition in the sea is to e to the utmost the volume of water em- d in gaging the cement, and it is here the effect of puzzuolana, quite independ- f its chemical action, becomes of value.

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nd Pressure.—Messrs. Stanton and Bairs- iave recently made some experiments at National Physical Laboratory, London, bring out a new and practically very ble fact—namely, that pressure is not ame on large surfaces as on small ex- iental models. If, for example, a given velocity is brought to bear on a square of surface it will be 18% less per square than if it were directed on 100 square of surface. It was demonstrated, too, this relation is constant for flat forms, ver complicated. A builder or engineer knows that a structure may be exposed wind of eighty miles per hour and that ressure per square foot as determined by t is, say, x pounds, should allow for his r construction 20% extra. The reason his seems to be the more thoroughly re- l pressure on the lee side of a larger

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ect of Heat on Reinforced Concrete.— All concrete mixtures when heated ghout to a temperature of 1,000° to ° F. will lose a large proportion of their gth and elasticity, and this fact must be remembered in designing.

) All concretes have a very low thermal ictivity and therein lies their well- n heat resisting properties.

) As a result of this low thermal con- vity, two to two and a half inches of con- covering will protect reinforcing metal injurious heat for the period of any or- y conflagration (provided, of course, that oncrete stays in place during the fire).

) Reinforcing metal exposed to the fire not convey by conductivity an injurious nt of heat to the embedded portion.

) Gravel concrete is not a reliable or fire-resisting aggregate.—Professor Ira Woolson, in a paper read before the Am. for Testing Materials.

Bobbinite: A Relatively Safe Explosive.— There is no such thing as a completely safe explosive—that is to say, there is no explosive known which, under any conceivable circumstances, might not ignite gas or dust, or a mixture of gas and dust. But the relative safety of the very best and highest class of explosives, as compared with gunpowder, is so great that the difference of safety in degree practically becomes a difference in kind.

Bobbinite is classed as a non-detonating mechanical mixture which consists of a high-grade gunpowder containing but little sulphur, mixed with starch and paraffin-wax, and compressed into a pellet coated with paraffin-wax. It was tested in various ways, and practical experiments were conducted with it in four seams of widely varying character, when it produced marked advantages in coal-getting over other substances of a similar type. It is the opinion, however, that the experiments indicated that Bobbinite and several other explosives of this character, where insufficiently confined, are more likely to explode gas than those explosives which give a high "charge limite" when tested without stemming. The "charge limite" is defined as the maximum charge which, in a series of ten shots fired unstemmed from a gun, fails to ignite an explosive mixture of gas and air in an experimental gallery.—"Compressed Air."

Experiments on Wind-Power.—Although, for any purpose requiring a more or less continuous supply of power, the wind is a wholly unsuitable source of energy, there are, nevertheless, many cases in which it can be utilized with advantage. Even if it has to be supplemented by a stand-by such as an oil engine, and worked in conjunction with a storage battery (which is generally an indispensable adjunct), wind-power may prove a source of economy. A few results derived from a series of experiments which has been carried on for some years by the Danish Government may, therefore, be of interest.

The velocities of the wind which are practically utilizable lie betweeen 10 and 50 ft. per second, and the motor must be so constructed as to adapt itself automatically to all conditions, including storms. It has been found that a motor with only four wings is the best, and that if the surface of the wings in square feet is S, the velocity of the wind V in feet per second, and the output in horse-power is W, then $W = S\ V^2 \div 456{,}000$. Thus, for a surface of 100 sq. ft., with velocities of 10,

20, 30 and 40 ft. per sec., the power available is 0.22, 1.8, 6 and 14 HP. At the experimental station of Askow, with a petrol-motor as stand-by and a storage battery, an installation of 450 incandescent lamps has been successfully run for two years, at a fair profit even after allowing for interest and sinking fund charges on a 25-year basis.—"Electrical Review," London.

Steel Hardening by Electricity.—In a recent issue of Le Génie Civil, there is described by T. Garnier a comparatively new and simple method for hardening steel by electricity. The tool to be hardened is put in electric connection with the positive pole of the battery or other source of current; in similar connection with the negative pole, there is a cast iron tank full of carbonate of potash dissolved in water. The current is regulated by a rheostat. The tool is plunged to the desired depth in the solution, just as for hardening in the usual manner, the current is then switched on and the tool heated to the same degree as would be required in ordinary hardening. When the proper temperature has been reached and held for the desired time, the current is switched off and the tool left in the bath, which latter, by the simple act of switching off the current, is at once converted into a hardening bath.

Another method, which permits of hardening places on the surface of pieces, where the dipping process would not accomplish the desired object, is local heating with the electric arc. Here the tool or other article is laid on a copper block, and an ordinary arc carbon held in a safety holder; the electric connections with holder and block being made, the carbon pole is touched to the piece to be locally hardened. Of course the heating is both intense and local; the work-piece is at once plunged into the ordinary hardening bath, and when one place is hardened the next may be heated, and so on. The electric current may also be used to draw the temper of a hollow object. Instead of using a red-hot iron rod to plunge in the bore, a cold rod is employed, which is used as a resistance in the circuit of a secondary current of about 2 volts tension. The temperature of the iron rod gradually rises, and when the work-piece has reached the desired color the current is shut off. This method is said to produce less liability to cracking than the old-fashioned way of drawing the temper with a hot rod. It is particularly recommended for large hollow mills. The great advantage consists in the perfect regulation possible by means of a rheostat, and in the possibility of getting exactly the same temperature every time for similar objects, once the right heat and color are attained.—"Mining Reporter."

Transmutation of Elements.—In a recent issue of the "Chemiker Zeitung," Professor Wilhelm Ostwald, the well-known chemist at the University of Leipzig, discusses Sir William Ramsay's discovery that elements heretofore regarded as unchangeable are capable of transmutation. Professor Ostwald alludes to it as "the greatest scientific achievement since the discovery of the practicability of applying the electric dynamo to mechanics," and he describes at length the process by which Sir William Ramsay converts radium into helium and produces neon, krypton, lithium, and sodium. He then says: "When I visited Ramsay in London he demonstrated to me that he could produce lithium from copper by the action of a solution of sulphate of copper on the emanations of copper. After the copper had been extracted, by means of sulphuretted hydrogen, from the solution which had been in contact with the emanations of radium, a residue of lithium remained. Since then, as I have seen from the proofs of an article that Sir William Ramsay is about to publish, he has not only confirmed this discovery, but has added to it. He has proved that, should the emanations of radium alone or mixed with hydrogen, be left in a vessel, after a time helium will be produced. In the event of the emanations coming into contact with water, instead of helium, neon with slight traces of helium is the result. Then by dissolving in the solution a heavy metal (the experiments were carried out with the nitrate of silver and the sulphate of copper) xenon or krypton is produced. Other substances are also present, but no exact definition of their character has been obtained, owing to the infinitesimal quantities in which they occur. Sodium and calcium have been observed among them, but the latter may possibly have come from the experiments having been made in glass vessels."—"The Times Engineering Supplement" (London).

Bricks made of sand and lime and hardened in the air are used largely in communities where there is no clay from which clay brick can be made, but where an abundance of sand can be found.

BOOK DEPARTMENT

SOLUBILITIES OF INORGANIC AND ORGANIC SUBSTANCES.—A Handbook of the Most Reliable Quantitative Solubility Determinations. Compiled by Atherton Seidell, Ph. D. (J. H. U.), Bureau of Chemistry, U. S. Department of Agriculture. New York: D. Van Nostrand Co. Cloth; pp. 380; many tables. $3.00, net.

Reviewed by August P. Bjerregaard.*

Among the physical properties of substances which are important from the point of view of the chemical technician, as well as the theoretical chemist, the solubility of a body in water or other liquids is of the greatest significance. In very many cases the whole process of manufacture or purification of a chemical substance depends directly upon its properties in this respect. Sometimes obscure or little known facts relating to this matter when put to use effect enormous advances in industry, as for example the application of the solubility of gold in dilute cyanide solutions.

Because of the very great importance of the subject it would naturally be expected that many books would have been published upon this subject. But as a matter of fact, only three are known.

The first work ever given to the world on this subject was F. H. Storer's "First Outlines of a Dictionary of Solubilities of Chemical Substances," published in 1864. While as far as this work goes in its statements of facts, it is still of value, nevertheless it is now hopelessly out of date because of the enormous strides made in the acquisition of new facts in the last half century. Storer's work was compiled entirely from general text-books whose statements were neither compared with the original sources, nor in any way critically selected. Quantitative data are very few, but qualitative data are abundant, and inorganic and organic compounds are equally treated.

In 1896 came A. M. Comey's "Dictionary of Chemical Solubilities," which was never finished, only the first part, concerning inorganic bodies, having seen the light. In this work none of the enormous mass of carbon compounds containing hydrogen directly united to the carbon are treated.

Quantitative data are much more numerous than in Storer's work, but the majority are still qualitative. Comey followed Storer's plan of obtaining all his data from general chemical works and in making no critical selections. In spite of its shortcomings, this work is still of great usefulness.

Lastly, Atherton Seidell has produced a work on this subject, departing radically from the former two authors in four respects.

1. He tabulates only quantitative results.
2. All data are taken exclusively from the original periodical sources.
3. Only data published since 1875 are considered.
4. He has in very many cases recalculated the original data into more convenient shape. This he has done more especially when there were more than one set of determinations for a single substance. These have then been often combined into one table by the author. In many cases this plan has enabled the author to state the solubility results throughout the book in a uniform tabular form, for regular intervals of temperature, usually 10° C., and in terms of weight of dissolved substance per given weight of solvent or solution, or both. The labor involved in all this recalculation must have been enormous, but the superior usefulness thereby attained justifies the author's efforts.

The data are arranged conveniently in alphabetical order under the usual English names of the solutes, with a very full index of cross references. Rightly, no distinction is made between inorganic and organic compounds; both are on an equal footing and equally completely treated.

The wisdom of omitting entirely all qualitative data seems somewhat doubtful to the reviewer. Seidell's assumption, to justify this exclusion, "that qualitative determinations, if desired, can be readily made by simple tests in the laboratory," is not well taken, because it frequently happens that information is desired concerning the solubility of a substance, or indeed often of a series of substances, that may not be at hand for tests, simple or otherwise.

A few misprints have been noticed; for example, on page 87, line 3 from the top, "calcium carbonate" instead of "calcium bicarbonate." On page 170 the specific gravity of ligroin solution in water is given as 0.6640, which evidently should be 0.9940. On page

*Analytical Chemist, New York City.

259 the reference under potassium permanganate to J. Amer. Chem. Soc. vol. 28, should be to page 1136.

The presswork is well done, the type is clear, the typographical arrangement of the tables is excellent. A few of the figures therein have been compared with the originals by the reviewer without finding any errors.

Seidell's work will be invaluable not only to all classes of chemists, but to all technicians who need information in this line.

NEW BOOKS.

Aerial Navigation.

NAVIGATING THE AIR.—A Scientific Statement of the Progress of Aeronautical Science up to the Present Time. By The Aero Club of America. New York: Doubleday, Page & Co. Cloth, 5 × 8 ins.; pp. vii. + 259; numerous plates and text illustrations. $1.50 net.

THE PROBLEM OF FLIGHT.—A Text-Book of Aerial Engineering. By Herbert Chatley, B. Sc. (Engineering), London, Lecturer in Applied Mechanics, Portsmouth Technical Institute. London, England: Charles Griffin & Co., Ltd. Philadelphia: J. B. Lippincott Co. Cloth, 6 × 9 ins.; pp. 119; 1 plate and 81 text illustrations. $3.50 net.

Chemistry.

CHURCH'S LABORATORY GUIDE.—A Manual of Practical Chemistry for Colleges and Schools, Specially Arranged for Agricultural Students. Revised and partly rewritten by Edward Kinch, F. I. C., etc., Professor of Chemistry in the Royal Agricultural College, Cirencester. Eighth edition. New York: D. Van Nostrand Co. Cloth; 5 × $7\frac{1}{2}$ ins., pp. xvi. + 349; 42 illustrations in the text. $2.50 net.

EXPERIMENTAL AND THEORETICAL APPLICATIONS OF THERMODYNAMICS TO CHEMISTRY.—By Dr. Walther Nernst, Professor and Director of the Institute of Physical Chemistry in the University of Berlin. New York: Charles Scribner's Sons. Cloth $7\frac{3}{4}$ × $5\frac{1}{4}$ ins.; pp. 123; eight illustrations in the text and 21 tables. $1.25 net.

Civil Engineering.

DETAILS OF MILL CONSTRUCTION.—By Hawley Winchester Morton, Architect. Boston, Mass.: Bates & Guild Co. Cloth; $9\frac{1}{2}$ × $12\frac{1}{2}$ ins. 25 plates. $2.

HANDBUCH FUER EISENBETONBAU (Handbook of Reinforced-Concrete Construction).—Edited by F. von Emperger. Vol. III.: Examples from Practice. Part 2, prepared by R. Wuczkowski, Fr. Lorey, B. Nast, A. Nowak. Berlin, Germany: Wilhelm Ernst & Son. Paper: $7\frac{1}{4}$ × $10\frac{1}{2}$ ins.; pp. 642; 503 illustrations in the text and one folding plate. 15 marks; American price, $6. Parts 1 and 2, Vol. III., bound together. 34 marks; American price, $13.60.

STEREOTOMY.—By Arthur Willard French, M. Am. Soc. C. E., Professor of Civil Engineering, Worcester Polytechnic Institute, and Howard Chapin Ives, Assistant Professor of Civil Engineering, University of Pennsylvania. Second Edition. New York: John Wiley & Sons. London, England: Chapman & Hall, Ltd. Cloth; $5\frac{3}{4}$ × $9\frac{1}{4}$ ins.; pp. 119; 47 illustrations, mostly in the text, and 22 folding plates. $2.50.

Electrical Engineering.

A HANDBOOK OF WIRELESS TELEGRAPHY.—Its Theory and Practice. For the Use of Electrical Engineers, Students and Operators. By James Erskine Murray, D. Sc., F. R. S. Edinburgh, M. I. E. E. London. Crosby Lockwood & Son. New York: D. Van Nostrand Co. Cloth; $5\frac{1}{2}$ × $8\frac{1}{2}$ ins.; pp. xvi. + 322; 131 illustrations in the text and 11 tables. $3.50, net.

KURZES LEHRBUCH DER ELEKTROTECHNIK (Brief Text-book of Electrical Engineering).—By Dr. Adolf Thomälen. Third Edition. Berlin, Germany. Julius Springer. Cloth; $6\frac{1}{4}$ × $9\frac{1}{4}$ ins.; pp. 325; 338 illustrations in the text. 12 marks; American price, $4.80.

TABLES FOR THE COMPUTATION OF ILLUMINATION.—Giving the Values for Different Angles and Their Corresponding Distances of the Illumination per Unit of Light and the Light Required for Unit Illumination. (Compiled by William B. King.) Dorchester, Mass.: The Author (11 Merlin St.) Flexible leather; 4 × $5\frac{1}{2}$ ins. $2, net.

THE CONSTRUCTION OF DYNAMOS (Alternating and Direct-Current).—A Text-Book for Students, Engineer-Constructors, and Electricians-in-Charge. By Tyson Sewell, A. M. I. E. E., Lecturer and Demonstrator in Electrical Engineering at the Polytechnic, Regent St., London. London: Crosby Lockwood & Son. New York: D. Van Nostrand Co. Cloth; $5\frac{3}{4}$ × 8 ins., pp. xii. + 316; 233 illustrations in the text. $3.00, net.

Mechanical Engineering.

FUEL, WATER AND GAS ANALYSIS.—For Steam Users. By John B. C. Kershaw, F. I. C., Author of "Smoke Prevention," etc. New York: D. Van Nostrand Co. Cloth, $5\frac{1}{2}$ × $8\frac{1}{2}$ ins. pp. xii. + 167; 50 illustrations in the text. $2.50, net.

LUBRICATION AND LUBRICANTS. — A Treatise on the Theory and Practice of Lubrication, and on the Nature, Properties and Testing of Lubricants. By Leonard Archbutt, F. I. C., F. C. S., Chemist

to the Midland Railway Co., and R. Mountford Deely, M. Inst. M. E., F. G. S., Locomotive Superintendent, Midland Railway. Second Edition, Thoroughly Revised and Enlarged. London, England: Charles Griffin & Co. Cloth; 5¼ × 8¾ ins.; pp. xxx. + 528; 157 illustrations in the text. $6, net.

THE MARINE STEAM TURBINE.—A Practical Description of the Parsons Marine Turbine as Presently Constructed, Fitted and Run, Including a Description of the Denny & Johnson Patent Torsion Meter for Measuring the Transmitted Shaft Horse-Power, and Containing Fifty Questions (with Solutions) on Elementary Turbine Design. By J. W. Sothern, Author of "Verbal Notes and Sketches for Marine Engineers," etc. Second Edition. New York: D. Van Nostrand Co. London, England: Whittaker & Co. Cloth; 5½ × 8½ ins.; pp. 163; folding and other plates and text illustrations. $2.50 net.

Mining Engineering.

DREDGING FOR GOLD IN CALIFORNIA.—By D'Arcy Weatherbe, M. Can. Soc. C. E. San Francisco: Mining and Scientific Press. Cloth; 6 × 9 ins.; pp. 217; 103 illustrations, including many full-page half tones. $4.00.

SHAFT SINKING IN DIFFICULT CASES.—By J. Riemer. Translated from the German by J. W. Brough, Assoc. M. Inst., C. E. London, England: Charles Griffin & Co. Philadelphia: J. B. Lippincott Co. Cloth; 6 × 9 ins.; pp. 122; 19 folding plates and 18 text illustrations. $3.50, net.

Railways.

AMERICAN RAILWAYS AS INVESTMENTS.—A Detailed and Comparative Analysis of All the Leading Railways, from the Investor's Point of View; With an Introductory Chapter on The Methods of Estimating Railway Values. By Carl Snyder. New York: The Moody Corporation. London, England: Frederic C. Mathieson & Sons. Cloth; 6¼ × 9½ ins.; pp. 762; one folding map. $3.20, net; by mail, $3.40.

Sanitary Engineering.

RECHERCHES SUR L'EPURATION BIOLOGIQUE ET CHEMIQUE DES EAUX D'EGOUT. (Researches on the Biological and Chemical Purification of Sewage).—Carried out at the Pasteur Institute of Lille and the Experiment Station of Madeleine. By Dr. A. Calmette, assisted by E. Rolants, E. Boullanger, A. Buisine, F. Constant and L. Massol. In two volumes. Paris, France: Masson & Cie. Paper; 6½ × 10 ins. Vol. I.: p. 193; 5 plates and 15 text illustrations. Vol. II.: pp. 214; 2 plates, 24 diagrams and 45 text illustrations.

We have just received from the Engineering Experiment Station, of the University of Illinois, Bulletin No. 13, "An Extension of the Dewey Decimal Classification Applied to Architecture and Building." This greatly extended classification has been in use in a more comprehensive form in the Department of Architecture for many years, but it has never before been published. It forms a supplement to the extended classification applied to the branches of engineering previously issued in Bulletin No. 9. It is preceded by a very brief explanation of the exceedingly valuable system invented and introduced by Dr. Melvil Dewey for the classification of books and literary materials, but which has since been found to be the best known method for arranging all tangible things and ideas. For the convenience of persons not fully conversant with the system, and for finding the proper numbers quickly, a relative index of subjects has been added. In its present form it is believed that this bulletin will prove useful to architects, engineers and constructors in classifying books, pamphlets, articles in periodicals, data and all other material relating to architecture and construction. Copies may be secured upon application to the Director of the Engineering Experiment Station, Urbana, Ill.

At the time of the first commercial production of liquid air, several years ago, a number of untenable claims were made as to its practical applications. One of the most valuable uses to which the liquefaction of air has been put is that of the subsequent separation of the oxygen and nitrogen by fractional distillation and rectification. The possession of such a substance as liquid air, however, has proved of much value in the study of the behavior of various materials at low temperatures. It is generally assumed, for instance, that at very low temperatures metals become brittle and even fragile, and in numerous cases the breaking of steel rails in winter weather has been attributed to this cause. By the use of a bath of liquid air it has been found practicable to test various metals and alloys at temperatures as low as 180°, and this has led to the discovery that while many steels have their tensile strength increased, their ductility lowered and their brittleness raised at low temperatures, this is not always the case. R. A. Hadfield, a well known British metallurgist, has shown that a nickel manganese steel can be made which will be as tough if not tougher at —180° C. than it is at ordinary atmospheric temperatures, and this, too, without material change in the tensile strength.

INDUSTRIAL ENGINEERING

A RECORD OF NEW TOOLS, PROCESSES, MATERIALS AND APPLIANCES

CORRUGATED STEEL SHEET-PILING.

Corrugated steel sheet-piling is the result of the careful study of experienced engineers with the object of originating a steel pile section of shape particularly designed to give the utmost strength with the minimum weight of metal. At the same time it was sought to provide a steel piling which could easily be manufactured in a great many sizes and weights. That this was accomplished is proved by the description which follows.

This type of steel sheet-piling is manufactured from standard steel plates, corrugated and provided with a central clip, which locks the adjoining sections of the piling when they are in position. Being made from plates, corrugated steel piling can be furnished in an almost unlimited range of sizes and weights, and is, therefore, adapted to the greatest possible variety of conditions. This feature is certainly very important, as it permits the selection of a steel piling most economically adapted to the requirements of any particular case. It is certainly not good engineering to use the same weight of steel piling under any and all conditions, any more than it would be to use the same weight of beams or columns for all conditions of loading in a bridge or a building.

There is probably no other shape of metal which, for equal weight, will have the stiffness of a corrugated section, and this is the [illegible]

[illegible]

The corrugated section, on account of its configuration, presents an ideal surface for the driving and it is easier to drive it straight because it is quite symmetrical. All the driving is done on the corrugated plate, as the clip is cut back from each end and, therefore, all strain on the [illegible] is eliminated. Furthermore the binding which results from the inevitable [illegible] in rolled sections and requires an exceedingly heavy hammer for driving, is practically absent in the corrugated sections. The latter are formed from cold plates, and, therefore, are more nearly straight and uniform than sections finished hot. Moreover, the clearance in the lock can be made such as to obviate all possibility of binding, yet, owing to the shape of the corrugated pile, there is no danger that the inside member will escape in hard driving among stones.

Corrugated steel sheet piling is manufactured and sold by the Wemlinger Steel Piling Co., [illegible] Broadway, New York, and this company has enough confidence in its steel piling to lease it to contractors or to drive it and pull it for them. A cross-section of the Wemlinger piling is shown in the advertising pages of this issue.

A WHITE CEMENT.

[illegible] stone, found in the Berkshire [illegible] is the basis of the new white cement [illegible] "Snow White." This cement has been thoroughly tested by analytical chemists [illegible] and the results have [illegible] by the producers. As a [illegible] stone and [illegible] it is [illegible] by any cement on [illegible] pure white color [illegible] One of the features [illegible] impervi[illegible] numerous tests [illegible] our ab[illegible] weather [illegible] & [illegible] have been [illegible] interior or exterior [illegible] and also

they can furnish the cement in any shade ...ed by architects.

A UNIQUE FOUNDATION.

...interesting piece of foundation work, il...ating the increasing use of concrete, has been completed for the Empire Works ...e Standard Oil Company at Claremont ... Jersey City, N. J., by the Foundation ...pany, 115 Broadway, New York.

...addition to the plant called for the con...tion of a foundation on some filled-in ...nd at the junction of the salt meadow ...upland. To obtain a proper bearing it ...necessary to go 20 ft. beneath the exist...surface, the ground-water level being 10 ...elow. To carry a heavy concrete footing ...e bearing stratum was too expensive, and ...nber pile foundation with a heavy con... cap was rejected for a similar reason, ...it was determined to erect the structure ... foundation of Simplex Concrete Piles.

... heavy pile driver with reinforced leads ...used to drive a hollow steel form, hav...an outside diameter of 16 ins., and ter...ating with a patent shoe or jaw, to re...nce, by using a 3,000-lb. hammer. When ...form reached the bearing stratum a small ...a of 1-2-4 concrete was dropped inside ...the form raised about a foot by a heavy ...ng device attached to the leads; the pat...jaws opened by dropping a heavy rammer ...op of the charge of concrete. This action ...only opens the jaws, but forces the con... out into the surrounding material. An...r charge of concrete is inserted and the ... again pulled up a short distance. This ...ess is repeated until the form is entirely ...of the ground and the pile space has been ...l with concrete.

...he Simplex Pile thus formed by the ram...g of the concrete into the surrounding ma...l has a very rough exterior surface, and, ...equently, a great skin friction, which, in ...ain soils, is a very important factor in the ...orting power of the pile.

... addition to this, the pile is of the same ...eter throughout, having the same area at ...bearing points as it has at the top, and ... transmit its load as a column. In the ...red pile the area at the bottom is very ...h smaller than the top, and any load sus...ed by the pile in excess of the fractional ...tance, is concentrated on a very small ..., when the reverse result is what is de...l.

In wet or filled-in areas where the ground-water level is at a depth below the surface more than 6 ft., the concrete pile makes a cheaper foundation than any other type. This arises from the fact that with any other form of construction it is necessary to excavate to the solid stratum from which to start the concrete pier, or, in case of timber piles, it is necessary to excavate to water level, to cut off the piles, and then build the pier from that level. These facts, coupled with the relative bearing power of the concrete and timber pile (Simplex Concrete Piles having been tested to 60 tons per pile without any settlement, and are designed to support 25 to 30 tons each) makes a foundation of concrete piles from 25 to 50% cheaper than any other type.

TRADE CATALOGUES AND PAMPHLETS.

Hydraulic Cement.

HYDRAULIC CEMENT.—Western Cement Co., 227 W. Main St., Louisville, Ky. Paper; 3¼ × 6 ins.; pp. 16.

This booklet contains the results of a number of recent tests on the "Louisville Hydraulic Cement" manufactured by this company. This cement is a natural product, being made from limestone and shale, and is noted for its light color, slow rate of set and low cost. It is claimed that it will meet all of the requirements that may be exacted from the highest grade of Portland cement, and its extensive use in street pavement foundations and general masonry construction strengthen its reputation of three-quarters of a century as a trustworthy material for use in engineering structures.

Steam and Compressed Air Meters.

STEAM AND COMPRESSED AIR METERS, ETC.—The Sargent Steam Meter Co., 1320 First Nat. Bank Bldg., Chicago. Folder; 3½ × 6 ins.; pp. 8; illustrated.

This circular illustrates a number of metering devices and other apparatus, among them being meters for indicating the volume and weight of steam or air flowing through a pipe; an automatic gas calorimeter giving values in B. T. U. direct; an anglemeter for indicating the angular velocity variation from that of a uniform velocity of a flywheel during one revolution; a dust determinator for ascertaining the amount of dust, moisture and tar in manufactured and natural gases; a direct-reading draft gage; and an integrating dyna-

mometer, which is read weekly or monthly like a gas or water meter. Descriptive catalogs of all these appliances can be obtained by addressing the company.

Storage Batteries.

STORAGE BATTERIES FOR STATIONARY USE.—The Westinghouse Machine Co., E. Pittsburg, Pa. Catalog S-2, No. 700[illegible]; paper, 6 × 9 ins.; pp. 40; illustrated.

This catalog gives descriptions, cuts and prices of the company's complete line of batteries, also curves showing results of battery installation upon generator loads. A line of storage-battery industrial-railway trucks is also described.

Surveying Instruments.

ENGINEERING AND SURVEYING INSTRUMENTS.—The Buff & Buff Manufacturing Co., Jamaica Plain Station, Boston, Mass. Catalog No. 37. Paper; 6 × 9 ins.; pp. 11[illegible]; illustrated.

This handsomely gotten up catalog is devoted to the illustration and description of the well-known line of high-grade engineering, surveying, astronomical and mining instruments manufactured by this company; such as transits, theodolites, levels, sextants, current meters, dividing engines, and other instruments of precision. Many points of especial excellence are stated, prominent among them being the great care exercised in manufacture. Fourteen interior views of the more interesting portions of the shops are included.

Thermit Welding.

THERMIT WELDING PROCESSES.—Goldschmidt Thermit Co., [illegible] West St., New York City. Two Bulletins. Paper; pp. 2[illegible]; illustrated.

One of these bulletins describes firebrick molds for welding locomotive frames by the thermit process. The success attained in such work led this concern to overcome troublesome details which were often the cause of vexatious delay. This has been done by the development of fire brick molds. Appliances and tools for all such repairs are listed, together with the amounts of "thermit" and steel punchings for various sizes of repairs.

The second bulletin treats butt-welding of wrought iron and steel pipes and rods by this process. The actual operations are outlined and the necessary equipment described. It is stated that the process is not applicable for tubes of more than 6-in. diameter.

Water Filters.

DOMESTIC WATER FILTERS.—Naiad Filter Co., Sudbury Bldg., Boston, Mass. Paper; 3¼ × 7½ ins.; pp. 4; illustrated.

This folder briefly sets forth the advantages of a new domestic water filter, consisting of a metal case, in which is placed a tablet of specially prepared filtering material, renewable at a trifling cost at any time.

Waterproofing Compound.

WATERPROOFING COMPOUND.—Theodore F. Koch, 801 Globe Bldg., St. Paul, Minn.; 79 Dearborn St., Chicago, Ill. Paper; 5½ × 8½ ins.; pp. 8.

This pamphlet sets forth the properties and advantages of Wunner's Bitumen-Emulsion, a thick, black fluid, resembling coal tar or asphaltum, and which is readily and perfectly miscible with cement mortar and cement concrete for waterproofing purposes. It may be applied in the cement mortar mixture on moist walls and even on walls of masonry where the water is oozing through. It is said that it will adhere permanently to any clean, rough surface of stone, brick or concrete, but it does not attach well to an oily surface or a dirty coating, nor to unusually smooth surfaces. It is claimed that any wall or structure, under whatever water pressure it can withstand, may be made dry by applying the bitumen mortar to either the outside or inside surface.

Wood Pipe.

WOOD PIPE.—National Wood Pipe Co., San Francisco, Cal. Folder; 3½ × 6¼ ins.; pp. 8; illustrated.

Describes the machine-banded pipe made by this company in sizes up to 18 ins. diameter, 20 ft. long, and for pressures up to 300-ft. head. The staves are made from 1½-in. clear, dry redwood or fir, and the pipe is banded with heavily galvanized rod, further protection being given by coating with hot asphaltum or tar. Continuous-stave pipe is also furnished by this company in diameters from 10 ins. up to 10 ft. This pipe is always built in place, all material being shipped in knockdown form. This pipe is constructed to withstand pressures up to [illegible]-ft. head, and is especially fitted for use in power plants and in water systems where it is desired to deliver a large volume of water. It is easily constructed in the most inaccessible places, is durable, and is also the cheapest high pressure pipe of large diameter obtainable.

INDEX TO TECHNICAL ARTICLES IN CURRENT PERIODICAL LITERATURE

This Index is intended to cover the field of technical literature in a manner that will make it of the greatest use to the greatest number—that is, it will endeavor to list all the articles and comment of technical value appearing in current periodicals. Its arrangement has been made with the view to its adaptability for a card-index, which engineers, architects and other technical men are gradually coming to consider as an indispensable adjunct of their offices.

Each item gives:

1. Title and author.
2. Name and date of publication.
3. An estimate of length of article.
4. A short descriptive note regarding the scope of the article—where considered necessary.
5. Price at which we can supply current articles.

The Publishers do not carry copies of any of these articles in stock, but, if desired, will supply copies of the periodical containing the article at the prices mentioned. Any premium asked for out-of-date copies must be added to this price.

The principal journals in the various fields of technical work are shown in the accompanying list, and easily understood abbreviations of these names are used in the Index.

The Editor cordially invites criticisms and suggestions whereby the value and usefulness of the Index can be extended.

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LIST OF PERIODICALS INDEXED

JOURNALS, PROCEEDINGS AND TRANSACTIONS OF AMERICAN TECHNICAL SOCIETIES

Journal Am. Foundrymen's Assn.
Journal Assoc. Engineering Societies.
Journal Eng. Soc. of Western Pa.
Journal Franklin Institute.
Journal West. Society of Engineers.
Proceedings Am. Soc. C. E.
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Proceedings Engineers' Club, Philadelphia.
Proceedings New York R. R. Club.
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Proceedings St. Louis Ry. Club.
Proceedings U. S. Naval Institute.
Transactions Am. Inst. Electrical Engineers.
Transactions Am. Inst. Mining Engineers.
Transactions Am. Soc. Mechanical Engineers.

(*Continued on second page following.*)

TECHNICAL PERIODICALS

American Builders Review

A Journal Devoted to the Architects, Contractors, Engineers and Builders of the Pacific Coast.

$5.00 per annum in the U. S.—Other Countries, $6.00. Single copies, 50 cents.

643 Stevenson St., SAN FRANCISCO, CAL.

The Canadian Municipal Journal

Official Organ of the Dominion and Provincial Unions of Municipalities.

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Address: 237 West 39th St., NEW YORK CITY.

Engineering-Contracting

A Weekly Journal for Civil Engineers and Contractors; with which is incorporated

ENGINEERING WORLD and CONTRACT NEWS.

Established 1891—Every Wednesday—$2 a Year.
Single copies 10 cents.

353 Dearborn St., CHICAGO, ILL.

Engineering News

A Journal of Civil, Mechanical, Mining and Electrical Engineering.

Weekly, $5.00 per year; single copies, 15 cents.

Published every Thursday by
THE ENGINEERING NEWS PUBLISHING CO.,
220 Broadway, NEW YORK.

The Industrial Magazine

A Monthly Magazine on Industrial Engineering for Engineers and Contractors.

Single copies 10 cents. One year $1.00

21 Park Row, NEW YORK.

The Iron Age

A Journal of the Iron, Steel, Metal, Machinery and Hardware Trades.

Subscription Price, $5.00 per year in the United States and Mexico; $7.50 in all other countries. Single copies 15 cents.

DAVID WILLIAMS CO.,
14-16 Park Place, NEW YORK.

Ores and Metals

A Semi-Monthly Review of Progress in Mining and Metallurgy.

$2.00 a year. 10 cents a copy.

DENVER, COLO.

The Railroad Gazette

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The Railway Age

Leader and acknowledged authority in all steam railway matters. Published every Friday; over 2,000 pages a year. Domestic, $4.00; Canada, $5.50; other foreign countries, $6.00; single copies, 10 cents.

THE WILSON COMPANY,
160 Harrison St., Chicago. 150 Nassau St., New York.
1529 Williamson Bldg., Cleveland, O.

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Established 1885.

For Roadmasters and Foremen, Engineers and Superintendents of Maintenance of Way, Superintendents and Foremen of Bridges and Buildings.

Monthly, $1.00 per year; single copies, 10 cents.

353 Dearborn St., CHICAGO, ILL.

Publishers

will find it to their advantage to have a one-inch card on this page, opposite the list of Periodicals Indexed. ASK US ABOUT IT

AMERICAN AND CANADIAN PERIODICALS

ylene Journal.
rican Architect.
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rican Engineer and R. R. Journal.
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Forestry and Irrigation.—See Adv.
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Glass and Pottery World.
Hardware.
Heating and Ventilating Magazine.
Horseless Age.
Ice and Refrigeration.
Illuminating Engineer.
Implement Age.
Industrial World.
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Inland Architect.
Insurance Engineering.
International Marine Engineering.
Inventive Age.
Iron Age.—See Adv. opposite.
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Journal of Electricity, Power and Gas.
Journal of U. S. Artillery.
Journal of Worcester Polytechnic Institute.
Judicious Advertising.
Machinery.
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Metal Worker, Plumber and Steam Fitter.
Mines and Minerals.—See Adv.
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Mining Reporter.
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Motor.
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Motor Boat.
Motor Car.
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Municipal Engineering.
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Ores and Metals.—See Adv. opposite.
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Plumber's Trade Journal.
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Power.
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Printers' Ink.
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Railway and Locomotive Engineering.
Railway and Marine World.
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Railway Master Mechanic.
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Scientific American.
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Selling Magazine.
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Southern Machinery.

Stevens Institute Indicator.
Street Railway Journal.—See Adv.
Technical World Magazine.
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Textile Manufacturer's Journal.
Tradesman.
Waterproofing.
Western Electrician.
Wood Craft.
Wood Worker.

PRINCIPAL BRITISH PERIODICALS

Agricultural Chronicle. (m.) London.
Architect. (w.) London.
Architects' Magazine. (m.) London.
Architectural Review. (m.) London.
Autocar. (m.) London.
Automobile Journal. (m.) London.
Automotor Journal. (w.) London.
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Builder. (w.) London.
Building Industries. (w.) Glasgow.
Civil Engineering. (w.) London.
Cold Storage. (m.) London.
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Commercial Motor. (w.) London.
Concrete & Constr. Engg. (b-m.) London.
Contract Journal. (w.) London.
Electrical Engineer. (w.) London.
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Implement and Machinery Rev. (m.) London.
India Rubber World. (m.) London.
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Journal of Gas Lighting. (w.) London.
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Railway Engineer. (m.) London.
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Sells' Commercial Advertiser. (w.) London.
Surveyor. (w.) London.
Textile Journal. (m.) London.
Timber Trades Journal. (m.) London.
Times Engineering Supplement. (w.) London.
Tramway and Railway World. (m.) London.
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PRINCIPAL FRENCH, GERMAN AND OTHER FOREIGN PERIODICALS

Annales des Ponts et Chaussées. (m.) Paris.
Beton und Eisen. (q.) Vienna.
Comptes Rendus de l'Acad. des Sciences. (w.) Paris.
Deutsche Bauzeitung. (b-w.) Berlin.
Dingler's Polytechnic Journal. (w.) Berlin.
Eisenbahntechnische Zeitschrift. (b-m.) Berlin.
Electricien. (w.) Paris.
Elektrochemische Zeitschrift. (m.) Berlin.
Elektrotechnik und Maschinenbau. (w.) Vienna.
Elektrotechnische Zeitschrift. (w.) Berlin.
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Revue de Mécanique. (m.) Paris.
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Zeitschrift f. d. Gesamte Turbinenwesen. .) Munich.
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Zeitschrift d. Ver Deutscher Ing. (w.) Berlin.
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Zentralblatt d. Bauverwaltung. (s-w.) Berlin.

INDEX TO ARTICLES

AUTOMOBILES

Bodies.

The Building of Automobile Bodies. E. F. Lake. Wood Craft—Sept, 07. 4 figs. 2700 w. 20c. Discusses the manufacture of tonneau, limousine and other styles of bodies.

Delivery Van.

A New 3,000-lb. British-Built Delivery Van. Comm Motor—Aug 1 07. 2 figs. 2000 w. 40c.

Design.

Basic Principles and Data for the Construction of Automobiles. E. Valentine. Z V D I—Aug 24 07. 50 figs. 6500 w. 60c.

Considerations in the Design of a Four-Cylinder Motor Car. Prac Engr—Aug 9 07. 6 figs. 3200 w. 40c. Continued. The front axle; steering.

Some Trends of Modern Automobile Design—IV. Victor Loughead. Motor Age—Aug 22 07. 11 figs. 8900 w. 20c. Different types of motors compared; ignition troubles; air and mixture volumes.

The Design of Petrol Engines for Motor Cars.—XI. Mech Wld—Aug. 2, 07. 2 figs. 2600 w. 20c. Discusses the disposition of valves, starting devices and vaporizers.

Fuels.

Does Alcohol Attack Metallic Surfaces? G. Lessard. Automobile—Aug. 29, 07. 1600 w. 20c. Translation of an article in "La Vie Automobile," by Charles B. Hayward, in which the question is answered in the negative.

Motor Car Fuels. Engr—July 26, 07. 1600 w. 40c. Summary of a report by the Fuels Committee of the Motor Union of Great Britain and Ireland.

Ignition.

A Chapter on Magneto Ignition. Elmer G. Willyoung. Automobile—Aug. 29, 07. 8 figs. 2500 w. 20c. Extract from copyrighted lecture, Correspondence School of Motor Car Practice, organized by the Maxwell-Briscoe Motor Company, Tarrytown, N. Y.

Materials of Construction.

Cast Aluminum for Automobile Work. Automobile—Aug. 15, 07. 5700 w. 20c. Extract from Part III of "Materials for Automobile Construction," by Thomas J. Fay.

Gray Cast Iron in Auto Construction. Automobile—Aug. 1 07. 4800 w. 20c. Extract from Chapter II, "Materials for Automobile Construction," by Thos. J. Fay.

Malleable Castings for Motor-Cars. I. P. I. Giron. Mech Wld—Aug. 23, 07. 4 figs. 1700 w. 20c.

Springs.

Construction of Motor Vehicle Springs. J. G. Rumney. Automobile—Aug. 29, 07. 2 figs. 2600 w. 20c. Paper read before the Society of Automobile Engineers at Buffalo, July 30-31.

Lever-Spring Suspension. Comm Motor—Aug. 1, 07. 2 figs. 1800 w. 40c. Describes an invention employing helicoidal springs which is designed to supersede laminated springs.

Tire.

A Resilient Tire for Heavy Work. Comm Motor—Aug. 1, 07. 3 figs. 1000 w. 40c. Describes a successful tire made of inserted staggered solid rubber pads.

Traction.

Carriage Traction on Common Roads. Prac Engr—Aug. 2, 07. 2600 w. 40c. Gives methods of computing the HP. required to propel vehicles on highways.

CIVIL ENGINEERING

BRIDGES.

Abutments.

Design of Reinforced-Concrete Structures: Abutments. Walter W. Colpitts. Ry Age—Aug. 23, 07. 2 figs. 3800 w. 20c. Gives the formulas and methods used in designing abutments for railway bridges.

Reinforced Concrete Structures on the Kansas City Outer Belt & Electric Railroad. Walter W. Colpitts. Ry Age—Aug. 2, 07. 4 figs. 1500 w. 20c. Gives illustrations and cost data for culverts, abutments and highway bridges.

Aqueduct.

Repairing a Limestone-Concrete Aqueduct Lining Destroyed by Soft Water. Eng News—Aug. 8, 07. 700 w. 20c.

Arch Design.

Influence Lines in Arches for Various Loadings. F. Koegler. Zent d Bauverwalt—July 24, 07. 10 figs. 1000 w. 40c.

Bridge Design.

The Proportioning of Steel Railway Bridge Members. Henry S. Prichard. Proc. of Soc. of Engineers, Western Penna. 15,000 w. 60c. Advance printing of an extended paper on the subject.

The Design of Timber Howe Trusses. R. Balfour. Eng News—Aug. 29, 07. 2 figs. 2000 w. 20c.

Bridge Failures.

Failure of Masonry Arch Carrying Erie Canal over Onondaga Creek, Syracuse, N. Y. Eng News—Aug. 8, 07. 6 figs. 2500 w. 20c.

The Locust Point Pier Collapse in Baltimore. Eng News—Aug. 8, 07. 2 figs. 900 w. 20c.

Erection.

Cost of Erecting a Draw Bridge of 236 Ft. Span. Eng-Contr—Aug. 21, 07. 600 w. 20c.

Details of Derrick Car and Methods of Work Adopted for Erecting a Railway Bridge. Roadmaster & Foreman—July, 07. 2 figs. 2400 w. 20c. Describes in detail the construction of a home-made derrick car.

Economical Methods of Highway Bridge Construction. Eng Rec—Aug. 24, 07. 4 figs. 2800 w. 20c. Discusses the use of adjustable falsework, hoists, etc.

Methods and Cost of Constructing Six Crib Piers, Three Howe Truss Spans and One Steel Draw Span. Eng-Contr—July 31, 07. 1000 w.

Notes on the Erection of Bridges. Ry Engr—Aug., 07. 4 figs. 3100 w. 40c. Floating out on pontoons. Rolling-out continuous girders.

Highway Bridge.

The Highway Bridge over the Rhine between Ruhrort and Homburg. W. Deitz. Z V D I—Aug. 10, 07. 45 figs. 3400 w. 60c.

Lift Bridges.

American and German Electrically Operated Lift Bridges. Frank C. Perkins. Ind Mag—Aug., 07. 12 figs. 1600 w. 20c.

Double Bascule Bridge at Duisbourg. Engr—Aug. 9, 07. 7 figs. 1900 w. 20c.

Quebec Bridge.

The Quebec Bridge: Superstructure Details. Eng Rec—Aug. 3, 07. 3 figs. 1200 w. Aug. 10, 1400 w. Aug. 24, 4 figs. 1500 w. Each 20c. Aug. 3: Diagonal members; Aug. 10: Anchor arm bottom chords; Aug. 24: Transverse bracing.

Reinforced-Concrete Bridges.

A Warped Surface Reinforced-Concrete Bridge. 1 fig. 600 w. 20c. Describes the automobile race-course at Weybridge, England, where records have recently been broken.

Cost of Reinforced-Concrete Arch Bridges. George P. Carver. Eng News—Aug. 22, 07. 2 figs. 900 w. 20c. Gives itemized cost of constructing arches from 50 to 100 ft. span for electric railway purposes.

Three Light Reinforced-Concrete Arch Bridges at Venice, Cal. Paul H. Ehlers. Eng. News—Aug. 20, 07. 4 figs. 1300 w. 20c.

Thebes Bridge.

The Thebes Railroad Bridge. Chas. A. Byers. Ind Mag—Aug., 07. 5 figs. 1000 w. 20c. Describes a 5-span continuous steel bridge over the Mississippi River, which is a type of the best modern construction.

Trestle.

A Pile Trestle Erected with a Pivotal Pile Driver. R. Balfour. Eng News—Aug. 15, 07. 4 figs. 7100 w. 20c. Describes a pile driver for driving inclined piles with the butts down.

Walnut Lane Bridge, Philadelphia.

Moving the Centering of the Walnut Lane Arch at Philadelphia. Eng News—Aug. 15, 07. 2 figs. 1100 w. 20c. Describes methods used on a bridge arch of 232 ft. span.

The Walnut Lane Bridge, Fairmount Park, Philadelphia. Eng Rec—Aug. 31, 07. 8 figs. 6400 w. 20c. Describes the methods employed in constructing a concrete arch of 233 feet span.

Viaducts.

Armored Concrete Viaduct at Deurne-Merxem (Holland). Engr—Aug. 9, 07. 9 figs. 3200 w. 40c.

Curved Girder Approach Viaduct of the Austerlitz Bridge over the Seine. R. Bonnin. Eng News—Aug. 15, 07. 12 figs. 4600 w. 20c. Describes this two-span steel viaduct and gives in an appendix the general theory of horizontally curved beams.

Richland Creek Viaduct, Indianapolis Southern Railway. Eng Rec—Aug. 3, 07. 2 figs. 900 w. 20c. Describes a single-track viaduct, 7 miles from Bloomfield, Ind., with a steel superstructure 132 ft. in maximum height and 2,215 ft. in length.

The Genesee River Viaduct, Erie R. R. Eng Rec—Aug. 31, 07. 6 figs. 2200 w. 20c.

EARTHWORK, ROCK EXCAVATION, ETC.

Earthwork Computation.

Diagrams for Earthwork Computation. Eng News—Aug. 15, 07. 1800 w. 20c. Communication from J. C. Trautwine, Jr., giving logarithmic diagrams and examples of their use.

Overhaul.

Calculation of Overhaul.—I. Can Cem & Concr Rev—Aug., 07. 1 fig. 1500 w. 20c.

Rock Crusher.

Breaking Piece for a Swinging-Jaw Rock Crusher. Gilmour E. Brown. Eng News—Aug. 15, 07. 1 fig. 500 w.

Rock Excavation.

Cost of Drilling and Blasting Soft Shale Rock Under Water; Using Drill Boats at Ashtabula Harbor, Ohio. Engg-Contr—Aug. 7, 07. 800 w.

Method of Excavating Rock in Large Masses. George C. McFarlane. Eng & Min Jl—Aug. 3, 07. 3500 w. 20c. Details experience in heavy granite excavation on the line of the Grand Trunk Pacific Railroad in the region north of the Lake of the Woods.

Shoring.

Retaining the Sides of a Large Excavation. Eng Rec—Aug. 24, 07. 2 figs. 1900 w. 20c. Describes methods used in the construction of steel frame building in New York City.

Trenches.

Machines for Digging Trenches and Grading Roads. Frank C. Perkins. Mun Engg —Aug., 07. 2 figs. 1200 w. 20c.

Cost of Trenching, Pipelaying and Backfilling for Pipe Sewer Construction at Centerville, Ia. Eng-Contr—Aug. 21, 07. 5000 w. 20c.

Unloader.

An Unloading Machine for Dump Cars in Building Embankments. 4 figs. 1100 w. 20c.

ENGINEERING CONSTRUCTION.

Buildings.

Construction Work on Jones & Laughlin's New Steel Plant. Charles M. Ripley. Ind Wld—Aug. 19, 07. 7 figs. 4200 w. 20c. Gives a detailed description of excavation for blast furnaces done by steam shovels and how the material was handled.

Construction Work on a Steel Plant. Chas. M. Ripley. Ind Mag—Aug., 07. 12 figs. 2800 w. 20c. Describes a preliminary work on new Jones & Laughlin plant, Aliquippa Park, Pa.

Cost of Shop Drawings for Structural Iron and Steel. Ralph H. Gage. Eng News—Aug. 8, 07. 2800 w. 20c. Gives data for 55 structures of various classes.

Model Plant for Handling Concrete. Charles M. Ripley. Cem-Era—Aug., 07. 7 figs. 4200 w. 20c. Sets forth interesting features of foundation work for steel plants at Aliquippa Park, Pa.

The Construction of the New York Central Office Building, New York. Eng Rec—Aug. 24, 07. 1 fig. 3900 w. 20c.

The Design and Construction of Industrial Buildings. D. C. Newman Collins. Eng Mag—Sept., 07. 11 figs. 8900 w. 40c.

The Hudson Companies' Building, New York. Eng Rec—Aug. 3, 07. 5 figs. 3100 w. 20c. Describes structural details of the down-town New Jersey terminal.

The Montgomery Ward Warehouse, Chicago. A. M. Ferry. Conc Engg—Aug. 15, 07. 10 figs. 1600 w. 20c. Describes construction of the largest concrete building in the world.

The New Warehouse of the Newark Warehouse Company. Eng Rec—Aug. 10, 07. 4 figs. 4800 w. 20c. Describes constructional details of a large 6-story reinforced-concrete building, embodying novel features in warehouse design.

Chimneys.

Stresses in Chimneys. A. Leon. Z V D I —Aug. 17, 07. 1 fig. 1200 w. 60c. Discusses the stresses in chimneys due to the varying temperatures at different points.

The Stability of Factory Chimneys. H. Mueller-Breslau. Zent d. Bauverwalt—Aug. 21, 07. 1 fig. 4000 w. 40c.

Dams.

A Buttressed Concrete Dam. Eng Rec—Aug. 24, 07. 3 figs. 2800 w. 20c. Describes the dam of the Beacon reservoir at Matteawan, N. Y.

Movable Crest Dam at the Water Power Development of the Chicago Drainage Canal. Eng Rec—Aug. 24, 07. 4 figs. 5000 w. 20c.

Reconstruction of a Masonry Dam for Increased Depth of Storage. Eng News—Aug. 29, 07. 2 figs. 1000 w. 20c.

Specifications for the Main Dams, Ashokan Reservoir, New York City Water Supply. Eng News—Aug. 1, 07. 4 figs. 3700 w. 20c.

The Construction of the Dam of the Nevada-California Power Co. Eng Rec—Aug. 3, 07. 2 figs. 1600 w. 20c. Describes a loose-rock dam about 1300 feet long, and 75 feet high, now under construction.

Reinforced-Concrete Construction.

A System of Reinforced Concrete. Engr—Aug. 23, 07. 2 figs. 1100 w. 40c. Describes a new English system for which a number of advantages are claimed.

Cost of Small Concrete Culverts. Alex R. Holliday. Eng News—Aug. 8, 07. 1 fig. 800 w. 20c.

Design of Reinforced-Concrete Structures: Flat Top Culverts. Walter W. Colpitts. Ry Age—Aug. 16, 07. 6 figs. 1000 w. 20c.

Economics of Reinforced-Concrete Floor Slabs. A. E. Bidell. Eng-Contr—Aug. 14, 07. 4 figs. 1400 w. 20c.

Gravel Screening and Washing Plants. Eng News—Aug. 1, 07. 3 figs. 3300 w. 20c.

Notes on Reinforced-Concrete Designing. Eng Rec—Aug. 3, 07. 1 fig. 3300 w. 20c. Appendixes to the British Architects' Reinforced-Concrete rules: Bach's slab theory, comparison of slab formulas, moments of inertia and ratio of moduli of elasticity.

Something New and Effective in Monolithic Concrete Construction. Concrete—Aug., 07. 6 figs. 2100 w. 20c. Describes the use of a novel steel plank holder which does away with the necessity of covering the whole extent of the work with lumber.

The Cost of Small Concrete Culverts. Eng-Contr—Aug. 28, 07. 1 fig. 300 w. 20c.

Roofs.

A Long-Span Truss Roof: Armory for Squadron C, New York National Guard, New York City. Eng News—Aug. 29, 07. 11 figs. 4500 w. 20c.

The New Charing Cross Station Roof. W. Noble Twelvetrees. Eng Rec—Aug., 07. 24 figs. 2800 w. 40c.

Tunnels.

Cost of Lining a [illegible]-ft. Railway Tunnel. Eng-Contr—Aug. [illegible] 07. [illegible] w. [illegible]

Lowering the Grade of a Tunnel at Kansas City. Eng News—Aug. [illegible] 07. [illegible] figs. [illegible] w. 20c.

Report of Cost of Concrete Work in Gunnison Tunnel. [illegible] Cement Age—Aug. 07. [illegible] figs. [illegible] w. 20c.

The Construction of the [illegible] Tunnel.—[illegible] Sci Am Sup—July 20, 07. [illegible] w. [illegible]

The Cost of Three Short Single-Track Tunnels. Eng-Contr—Aug. [illegible] 07. [illegible] w. 20c.

The Italian Approaches to the Simplon Tunnel. Engg—July [illegible] 07. [illegible] figs. [illegible] w. 40c.

Water Towers.

A Reinforced-Concrete Water Tower at Anaheim, Cal. Eng Rec—Aug. 24, 07. [illegible] figs. [illegible] w. 20c.

The Largest Reinforced Concrete Tower Ever Built in Place. Con Engg. [illegible] figs. 2000 w. 20c.

MATERIALS.

Cement and Concrete.

A Reinforced-Concrete Moist Closet for the Cement-Testing Laboratory. Ernest B. McCready. Eng News—Aug. [illegible] 07. [illegible] fig. 900 w. 20c. From a paper read at the annual meeting of the American Society of Testing Materials, Atlantic City, June 22.

Cast Stone. W. P. Butler. Cem Era—Aug. 07. [illegible] figs. [illegible] w. 20c. Third paper on the subject.

Concrete in Salt Water. [illegible] Age—Aug. 16, 07. 800 w. 20c.

Investigation of the Thermal Conductivity of Concrete and Embedded Steel and the Effect of Heat upon Their Elastic Properties. Ira H. Woolson. Eng News—Aug. [illegible] 07. [illegible] figs. [illegible] w. 20c. Paper read before the American Society for Testing Materials, Atlantic City, June 2[illegible].

Method and Cost of Mixing and Laying Bituminous Concrete for a [illegible] Eng-Contr—Aug. [illegible]

Summary of Tests on Reinforced-Concrete Beams at the University of Wisconsin Laboratories. Eng-Contr—Aug. [illegible] 07. [illegible] figs. [illegible] w. 20c.

Test of Concrete Columns. Arthur N. Talbot. Eng Rec—Aug. 10, 07. 8 figs. 3600 w. Describes tests recently made at the University of Illinois on plain or unreinforced-concrete columns, columns reinforced with circular hoops and bands, and columns reinforced with wire in the form of spirals or helices. A paper read before the American Society for Testing Materials.

Tests of the Adhesion of Steel to Concrete in Beams. Eng News—Aug. 15, 07. [illegible] w. 20c. Gives unusually high values for unit shears and adhesion stresses which have recently been reported to the Boston Society of Civil Engineers by Prof. L. H. Johnson of Harvard University.

The Control of Physical Test Results in Portland Cement. W. A. Aiken. Chem Engr—July 07. [illegible] w. Read at the meeting of the American Society for Testing Materials, June 21st.

The Properties of Portland Cement. Zeit f Bauverwalt—July [illegible] 07. [illegible] fig. 3 tables. [illegible] w. 40c. Gives results communicated by [illegible] to the Bureau for Testing Materials.

The Slipping Resistance of Steel and Brass in Concrete. [illegible] Eng Rec—Aug. [illegible] 07. [illegible] w. 20c. Describes experiments for ascertaining the adhesive strength of metal rods in concrete.

White Cement. A. S. Larson. Can Cem & Conc Rev—June, 07. [illegible] w. 20c.

Steel.

Priming Coats for Metal Surfaces. F. P. Cheesman. Eng News—Aug. [illegible] 07. 2500 w. 20c. From a paper read before the American Society for Testing Materials, at Atlantic City, June 22.

Tension Tests of Steel Angles With Various Types of End-Connection. Frank P. McKibben. Eng News—Aug. 22, 07. 3 figs. [illegible] w. 20c. Paper read before the American Society for Testing Materials, Atlantic City, June 22.

Test of a Cast Steel Beam. J. V. McAlpin. Eng News—Aug. [illegible] 07. 1 fig. 2900 w. 20c. Describes methods of testing beams for car bolsters and truck side frames, etc., to determine the strain in the extreme top and bottom fibers.

Tests of Cold-Twisted Steel Rods for Concrete Reinforcement. Jesse J. Shuman. Eng-Contr—Aug. [illegible] 07. [illegible] w. 20c. Paper read before the American Society for Testing Materials, Atlantic City, June 22.

Structural Mechanics.

[illegible] Calculating Moments of [illegible] Am Mach—Aug. [illegible] diagrams. [illegible] w. 20c. Gives [illegible] of the purpose of simplifying [illegible] relative to moments of [illegible] special sections composed of rectangles [illegible] such as tees, channels, I-beams, [illegible] and other shapes.

Graphical Methods for Calculating the Deflections of Beams. E. Aragon. Génie Civil—Aug. 24, 07. 4 figs. 3000 w. 60c.

Investigation of Distribution of Loads Over Slabs. Ind Mag—Aug., 07. 1200 w. 20c.

Study of Materials.

On the Study of Materials. Eng News—Aug. 29, 07. 4000 w. 20c. An editorial argument for recognition of the important place which the knowledge of materials holds in the engineer's life.

Timber.

Causes of Decay in Timber. C. W. Berry. Mun Engg—Aug., 07. 1600 w. Paper read before the U. S. Wood Preserving Association.

The Wood-stave Pipe Line of the Madison River Company. W. E. Belcher. Eng & Min Jl—Aug. 24, 07. 1 fig. 2000 w. 20c.

Wooden Stave Pipe. W. C. Hawley. Wood Craft—Sept., 07. 8 figs. 7700 w. 20c. Extracts from a paper discussed by members of the Engineers Society of Western Penn. and reported in their journal.

RIVERS, CANALS, HARBORS.

Breakwater.

Stone Breakwater Construction at Huron, Ohio. Wilson T. Howe. Eng News—Aug. 22, 07. 2 figs. 1400 w. 20c.

Canals.

The Maritime Canal Connecting Bruges and Zeebrugge (Belgium), the Breakwater and other Harbor Improvements. A. Dumas. Génie Civil—July 20, 07. 26 figs. 5000 w. 60c.

The Royal Commission of Canals and Waterways. Engr—Aug. 2, 07. 2 figs. 2700 w. 40c. VIII.—Gives particulars in regard to the Birmingham and the Shropshire Union canal systems.

Use of Cement on Great Panama Canal. Waldon Fawcett. Cem Wld—Aug., 07. 8 figs. 3600 w. 20c.

Dredging Work, Reports for.

A Report Card System for Dredging Work. Eng. News—Aug. 22, 07. 2 figs. 1120 w. 20c.

Floating Dock.

Floating Dock for Trinidad. Engg—July 26, 07. 700 w. 40c. Describes a new type of self-docking floating dock.

Flood Prevention.

Destruction of Debris Barrier No. 1, Yuba River, Cal. E. C. Murphy. Eng News—Aug. 8, 07. 3 figs. 2500 w. 20c. Gives details of barrier for holding back mining debris which was recently destroyed by undermining due to floods.

Floods and Means of Their Prevention. T. P. Roberts. From the July Proceedings of the Engineers' Society of Western Penna. 1 fig. 6000 w. 60c.

Riprapping Cribs, Cost of.

Cost of Riprapping Cribs with Breakwater Stone. Eng-Contr—July 31, 07. 800 w. 20c.

River Waves.

Progressive and Stationary Waves in Rivers. Vaughan Cornish. Engg—July 26, 07. 3000 w. 40c. I.—Progressive waves in rivers caused by added water.

Sea Wall.

Sea Defence Works at Hornsea. Engr—Aug. 9, 07. 10 figs. 2000 w. 40c. Gives details of a recently erected concrete seawall.

Siphon on Irrigation Canal.

A Reinforced-Concrete Siphon on an Irrigation Canal in Spain. Eng News—Aug. 1, 08. 9 figs. 1900 w. 20c.

West Neebish Channel.

The West Neebish Channel of the St. Mary's River.—I. Eng Rec—Aug. 3, 07. 3 figs. 4600 w. Aug. 10. 6 figs. 3600 w. Each 20c. Describes the nearly completed improvement of the West Neebish Channel which connects Lake Superior and Lake Huron, including the methods used in excavating and handling the material.

ECONOMICS

Contracts and Specifications.

Engineers' Contracts and Specifications from a Contractor's Point of View. James W. Rollins, Jr. Jl Assoc. of Engg Socs—July, 07. 7600 w. 60c.

Cost Accounting.

An Economical and Practical Cost System. B. A. Franklin. Am Mach—Aug. 8, 07. 8000 w. Describes a simple and effective shop cost-system for machine builders, the forms used and its installation in a factory.

The Expense of Business. Wm. H. Taylor. So Mach—Aug., 07. 1500 w. A paper read before the annual convention of Machinery Manufacturers at Cincinnati.

The Figuring of Factory Costs. Chas. Cloukey. Wood Craft—Sept., 07. 3600 w. 20c. Discusses some of the considerations that affect the keeping of a cost system and whereby it stands or falls.

What Constitutes Cost of Production. F. E. Webner. Ir Tr Rev—Aug. 1, 07. 2200 w. 20c. Eleventh of a series of articles on cost keeping.

Depreciation.

The Question of Depreciation and the Measurement of Expired Outlay on Productive Plant. P. D. Leake. Surv—Aug. 16, 07. 4100 w. 40c. I.—A plea for the study and use of better methods, from a paper read lately before the Institute of Directors.

Engineering Business.

Starting an Engineering Business. Sydney F. Walker. Prac Engr—July 26, 07. 3300 w. 40c. Concluded.

Factory Management.

Fixing Premium Rates Discussed. Forrest E. Cardullo. Am Mach—Aug. 1, 07. 1200 w. 20c. Suggests a new method based on minimum total cost and no limit to possible earnings.

Graphical Wall Records for the Production Department. H. L. Whittemore. Eng Mag—Sept., 07. 7 figs. 3700 w. 40c. Describes a system giving instant oversight of all work in progress.

Hints on Shop Management. H. F. Schmidt. El Ry Rev—Aug. 3, 07. 2500 w. 20c. Discusses time-keeping, issuing supplies, bonus systems, shop accounting, etc.

Personality in the Working Force. George H. Barbour. System—Aug., 07. 1 fig. 1000 w. 40c.

Profit Making in Shop and Factory Management. C. U. Carpenter. Eng Mag—Sept., 07. 5000 w. 40c. VIII.—Stimulating production by wage, stock and cost systems.

The Creation of Pension Funds for Employees. William R. Bowker. El Ry Rev—Aug. 3, 07. 2400 w. 20c.

The Promotion of Employees. J. F. Cairns. Cass Mag—Sept., 07. 3600 w. 40c.

Filing System.

More About Filing Systems. A. B. James. Am Mach—Aug. 22, 07. 1 fig. 1600 w. 20c. Describes modifications of a proposed envelope system.

Handling Sales Orders.

Time and Error Saving Accounting System. William E. Wilson. System—Aug., 07. 3 figs. 4000 w. 40c. A method of handling sales orders which ensures promptness in carrying out customers' wishes and at the same time obviates errors in the office work.

Industrial Education.

A Plea for a Machine Trade School. Arthur D. Dean. Machy—Sept., 07. 3500 w. 40c.

Training of Apprentices in Foundry Work. Ir Tr Rev—Aug. 15, 07. 2400 w. 20c. Describes a successful course of education introduced by the Ingersoll-Rand Co., Phillipsburg, N. J.

Invention.

Effect of Suggestion or Aid Received by an Inventor Upon Right to Patent. John Edson Brady. El Wld—Aug. 3, 07. 3000 w. 20c.

Laboratory Record System.

The Systematic Keeping of Laboratory Records. Richard K. Meade. Chem Engr—Aug., 07. 4 figs. 1000 w. 40c.

Library System of an Engineering Firm.

The Library System of Stone & Webster. G. W. Lee. Eng Rec—Aug. 24, 07. 6700 w. 20c. Paper of unusual interest read at the Asheville meeting of the American Library Association.

Municipal Ownership.

General Conclusion of the Municipal Ownership Committee of the National Civic Federation. Eng News—Aug. 15, 07. 4300 w. 20c.

South American Trade Openings.

American Trade Opportunities and Handicaps in South America. Lewis R. Freeman. Eng Mag—Sept., 07. 4300 w. 40c.

Wealth and Wage Earners.

Concerning Wealth and Wage Earners. Eng News—Aug. 1, 07. 3900 w. 20c. Editorial refutation of certain socialistic theories, based on U. S. Census reports.

ELECTRICAL ENGINEERING

ELECTROCHEMISTRY.

Electrolytes.

Influence of Non-Electrolytes and Electrolytes on the Solubility of Gases in Water. The Question of Hydrates in Solution. Jas. C. Philip. Elec—July 26, 07. 2000 w. 40c.

The Thermochemistry of Electrolytes in Relation to the Hydrate Theory of Ionization. W. R. Bousfield and C. W. Lowry. Elec—July 26, 07. [illegible] w. 40c. Paper read before the Faraday Society.

Hydrates.

Hydrates in Solution. Discussion of Methods Suggested for Determining Degrees of Hydration. Geo. Senter. Elec—July 26, 07. [illegible] w. 40c. Paper read before the Faraday Society.

On Stability of Hydrates as Indicated by Equilibrium Curves. Alex. Findlay. Elec—July 26, 07. 1000 w. 40c. Paper read before the Faraday Society.

Nickel Plating.

The Elliptic Nickel Anode. A. Frederick Collins. Iron Age—Aug. 22, 07. 3 figs. 2000 w. 20c. Describes an economical anode for nickel plating.

Storage Batteries.

Determination of the Size of a Storage Battery for a Given Load Curve. W. Peukert. Elek Zeit—July 18, 07. 3 figs. 2000 w. 40c.

Storage Batteries. C. Karapetoff. El Jl —Aug. 07. 7 figs. 3700 w. 20c.

ELECTROPHYSICS.

Capacity.

The Electrostatic Capacity Between a Vertical Metallic Cylinder and the Ground. A. E. Kennelly and S. E. Whiting. El Rev —Aug. 2, 07. 1 fig. 1200 w. 40c.

Eddy-Current Losses.

Eddy-Current Losses in Alternators with an Elliptical Rotating Field. R. Rudenberg. Elek u Masch—July 7, 07. 3 figs. 3000 w. 60c.

Electric Waves.

The Propagation of Electric Waves. El Rev—Aug. 2, 07. 6 figs. 5600 w. 40c.

Lightning.

Lightning Phenomena in the Clouds. Charles F. Steinmetz. El Rev—Aug. 3, 07. 2400 w. 20c. From an address delivered before the National Electric Light Association, Washington, June 15th.

Oscillating Arcs.

Note on Oscillographic Study of Low-Frequency Oscillating Arcs. J. T. Morris. El Rev—Aug. 9, 07. 21 figs. 3800 w. 40c. Paper read before Section G, British Association meeting, Leicester, July 30.

GENERATORS, MOTORS, TRANSFORMERS.

Compensation.

Synchronous Motor Compensation for Lagging Currents. Clarence P. Fowler. El. Wld—Aug. 10, 07. 6 figs. 5300 w. 20c. States some of the underlying principles which govern the operation of such apparatus when used for power service.

The Use of the Synchronous Motor as Phase Compensator. R. E. Hellmund. Elek Zeit—Aug. 1, 07. 2500 w.

Motors.

Circular Current Loci of the Synchronous Motor. A. S. McAllister. El Wld—Aug. 24, 07. 5 figs. 4300 w. 20c.

Synchronous Motors for Improving Power-Factor. William Nesbit. El Jl—Aug. 07. 7 figs. 4200 w. 20c.

The Properties of Various Types of Single-Phase Motors, Considered from a Common Point of View. H. Goerges. Elek Zeit—July 25, 07. 13 figs. 5000 w.; Aug. 1, 07. 12 figs. 6000 w. Each 40c.

The Starting, Regulating and Stopping of Continuous Current Motors. John T. Mould. El Engr—July 26, 07. 12 figs. 4800 w. Aug. 9, 3 figs. 6000 w. Each 40c. Paper read before the Association of Engineers in Charge.

Rectifier.

A Home-Made Alternating Current Rectifier. William F. Lent. Sc Am—Aug. 24, 07. 1 fig. 2100 w. 20c.

Rotary Converters.

Hunting in Rotary Converters. Norman G. Meade. El Wld—Aug. 3, 07. 5 figs. 1400 w. 20c.

Synchronizing.

The Synchroscope. S. R. Dodds. El Wld—Aug. 17, 07. 3 figs. 1300 w. 20c. Gives the fundamental principles of operating the apparatus.

Transformer.

The Use of Transformers as Adjustable Resistances. El Engr—Aug. 16, 07. 2 figs. 1000 w. 20c.

LIGHTING.

Electric Lighting in Germany.

Electric Lighting in Germany. Phil. G. Klingenberg. West Elecn—Aug. 17, 07. 4500 w. 20c. Paper read before the Washington convention of the National Electric Light Association, July 4-7,

Illumination.

The Concepts and Terminology of Illuminating Engineering. Dr. Clayton H. Sharp. El Rev—Aug. 10, 07. 3900 w. 20c. Presidential address delivered at the convention of the Illuminating Engineering Society, Boston, July 30.

The Elements of Inefficiency in Diffused Lighting Systems. Preston S. Miller. West Elecn—Aug. 10, 07. 1 fig. 2500 w. 20c. Abstract of a paper presented at the convention of the Illuminating Engineering Society, Boston, July 30.

Incandescent Lamps.

Experiments on Osram, Wolfram, Zircon and Other Lamps. J. T. Morris, F. Stroude and R. M. Ellis. Elecn—July 26, 07. 9 figs. 2400 w. 40c. Gives results of researches on the physical properties of recent metallic filament lamps.

Government Incandescent Lamp Specifications. El Wld—Aug. 3, 07. 3200 w. 20c. Gives specifications adopted by the Association of Government Electrical Engineers.

The Improvement of the Incandescent Lamp. R. Milward Ellis. El Engr—July 23, 07. 1800 w. 40c. Concluded.

Magnetite Arc Lamp.

The Magnetite Arc Lamp. El Engg—July 25, 07. 5 figs. 2200 w. 40c.

Mercury Arc Lamp.

Calculation of the Illuminating Power of the Mercury Vapor Lamp. K. Norden. Elek Zeit—Aug. 1, 07. 4 figs. 3000 w. 40c.

The Mercury Arc and its Technical Applications. J. Polak. Elek Zeit—July 25, 07. 13 figs. 6000 w. 40c. III. The Mercury Rectifier.

Photometry.

A New Comparison Photometer. Charles H. Williams. Am Gas Lt Jl—Aug. 19, 07. 1200 w. 20c. Describes a compact and portable instrument for measuring the light reflected from surfaces, such as the walls of a room, etc., in order to determine whether one method of lighting is better than another. A paper read at the Boston Meeting of the Illuminating Engineering Society.

Illumination Photometers and their Use. Preston S. Miller. Am Gas Lt Jl—Aug. 19, 07. 12 figs. 10,000 w. 20c. A paper read at the Boston meeting of the Illuminating Engineering Society.

Primary, Secondary and Working Standards of Light. Edward P. Hyde. W Elecn—Aug. 24, 07. 1700 w. 20c. Abstract of a paper presented at the convention of the Illuminating Engineering Society, Boston, July 30.

The Luminometer Method of Inspecting Street Arc Lamps. C. S. Downs. West Elecn—Aug. 17, 07. 1 fig. 1300 w. 20c. Abstract of a paper read before the Internat. Assn. of Munic. Electricians, Norfolk, Va.

The Use of the Spherical Photometer. R. Ulfricht. Elek Zeit—Aug. 8, 07. 4 figs. 7000 w. 40c.

PLANTS AND CENTRAL STATIONS.

Finance.

The Financial Side of the Central Station. A. D. Williams, Jr. El Wld—Aug. 3, 07. 3500 w. 20c. Discusses replacement charges due to depreciation, etc.

Municipal Lighting.

Municipal Electric Lighting. Ernest S. Bradford. Mun Jl & Engr—Aug. 21, 07. 7000 w. 20c. Gives an analysis of present conditions and statistics in the United States showing the relative growth of private and municipal plants.

Power from Refuse Destructor Plants.

Power from Refuse Destructor Plants for the Generation of Electricity. G. Dettmer. Elek Zeit—July 18, 07. 5 figs. 7000 w. 40c.

TELEGRAPHY AND TELEPHONY.

Poles.

Cost of Making and Setting Concrete Bases for Wood Poles. Eng Contr. 300 w. 20c.

Experiments With Concrete Telegraph Poles. G. A. Cellar. El Rev. 2400 w. A paper read before the convention of the Association of Railway Telegraph Superintendents, Atlantic City, June 19-21.

Seasoning of Telephone and Telegraph Poles. Henry Grinell. El Rev—Aug. 17, 07. 5400 w. 20c. From a circular of the United States Department of Agriculture, Forest Service.

Pupin Coils for Telephone Work.

On the Pupin Mode of Working Trunk Telephone Lines—I. Sir William Preece. El Engr—Aug. 16, 07. 1 fig. 2800 w. 40c. Paper read before the British Association at Leicester.

Simultaneous Telegraphy and Telephony.

Talking and Telegraphing Simultaneously Over the Same Line. N. C. Kissel. Am Tel Jl—Aug. 3, 07. 2 figs. 2500 w. Aug. 10, 7 figs. 2000 w. Aug. 24, 3 figs. 1700 w. Each 20c. Aug. 3-10, The Repeating Coil and the Simplex Circuit. Aug. 24, The Composite Ringer.

Telegraph Line Testing.

Wire-Testing. L. M. Jones. El Rev—Aug. 24, 07. 1900 w. 20c. Read before the convention of the Ass. of Ry. Telegraph Superintendents, Atlantic City, June 19-21.

Wireless Telegraphy.

Hot-Wire Relay for Selective Signalling. Richard Heilbrun. El Rev—Aug. 9, 07. 2 figs. 1400 w. 40c.

Notes on Tuning in Wireless Telegraphy. Sir Oliver Lodge. El Rev—Aug. 9, 07. 1400 w. 40c. Paper read before Section G, British Association meeting, Leicester, July 30.

The Arc and Spark in Radio-Telegraphy. W. Duddell. El Engr—Aug. 9, 07. 6300 w. 40c. Evening discourse delivered before the British Association at Leicester.

TESTS AND MEASUREMENTS.

Heating of Generators.

Experimental Investigation of the Heating of Electrical Machinery. L. Ott. Z V D I—July 20, 07. 3 figs. 3000 w. 60c.

High Potentials.

Measurement of High Potentials. W. Bradshaw and H. W. Young. Jl of El Power & Gas—Aug. 10, 07. 4 figs. 2700 w. 20c. Gives a brief outline of the more familiar methods of measurement, together with a description of a new electro-static voltmeter suitable for potentials from 10,000 to 200,000 volts.

Instrument Transformers.

Instrument Transformers. Charles C. Garrard. El Engr—July 26, 07. 7 figs. 2700 w. Aug. 9, 4 figs. 2400 w. Each 40c.

Iron Losses.

Determination of Iron Losses by Means of the Three-Voltmeter Method. H. Zipp. Elek u Masch—June 30, 07. 4 figs. 1500 w. 60c.

Phase Difference.

The Determination of Phase Difference in Three-Phase Plants. P. Humann. Elek Zeit—July 18, 07. 3 figs. 1000 w. 40c.

Polyphase Power Measurements.

Polyphase Power Measurements. C. A. Adams. Can Elec News—Aug. 07. 4 figs. 1500 w. 20c. Paper read before a recent meeting of the American Association for the Advancement of Science.

Power Chart for 3-Phase Circuits.

Power Chart for Three-Phase Circuits. A. A. Buchenberg. Engr—Sept. 2, 07. 2300 w. 20c. Gives a table showing the power in three-phase circuits with a power factor of unity and load balanced on the three phases.

Recording Meters.

Shunted Type of Graphic Recording Meters. Paul McGahan and H. W. Young. St. Ry Jl. 2 figs. 2000 w. 20c.

Resistance.

A Plan for Facilitating Rapid Measurement of Resistance with a Voltmeter. F. C. Greenwald. Am Tel Jl—Aug 24, 07. 1 fig. 1700 w. 20c.

Determining Combined Resistances Without Calculation. F. H. Neely. Power—Sept., 07. 800 w. 40c.

TRANSMISSION, DISTRIBUTION, CONTROL.

Aluminum Coils.

Aluminum Coils. Felix Singer. El Rev—July 26, 07. 2800 w. 40c.

Feeder Sizes.

Determining the Size of Feeders. Henry Docker Jackson. El Ry Rev—Aug. 17, 07. 1 fig. 2000 w. 20c. Describes methods of plotting feeder layout.

High-Tension Transmission.

Critical Study of the Thury High-Tension Power Transmission System. Elek u Masch—June 23, 07. 5 figs. 7500 w. 60c.

One-Phase High-Tension Power Transmission. E. J. Young. W Elecn—Aug. 10, 07. 4 figs. 3500 w. 20c. Describes a system of this nature having several desirable features not in common with either the direct-current or the three-phase system. A paper read before the American Institute of Electrical Engineers, Niagara Falls, N. Y., June 26.

Some New Methods of High-Tension Line Construction. Harold W. Buck. Eng News—Aug. 8, 07. 2000 w. 20c. Presented at the annual convention of the Am. Inst. E. E., June 26.

Insulation.

A New Type of Insulator for High-Tension Transmission Lines. E. M. Hewlett. W Elecn—Aug. 10, 07. 5 figs. 1200 w. Describes an insulator consisting of a flanged or petticoated disk with an enlarged central portion having two inter-linked semi-circular holes and used to insulate the inter-linked tie-wires. A paper read before the American Institute of Electrical Engineers, Niagara Falls, June 26.

Lightning Arresters.

The Electrolytic Lightning Arrester. R. P. Jackson. El Jl—Aug., 07. 4 figs. 2800 w. Describes electrolytic cells used for this purpose.

MISCELLANEOUS.

Electric Culture of Plants.

Electric Culture. El Rev—Aug. 24, 07. 600 w. 20c.

Electric Dumb-Waiters.

Electric Dumb-Waiter Machines and Systems. E. L. Dunn. El Wld—Aug. 3, 07. 6 figs. 2800 w. 20c.

Lightning Rods.

Lightning Rods for High Chimneys. El Wld—Aug. 3, 07. 1300 w. 20c.

INDUSTRIAL TECHNOLOGY

Acetylene for Signaling.

Night Signaling in the Army by Acetylene. Captain Leonard D. Wildman. Acetylene Jl—Aug. 07. 1 fig. 2500 w. 20c.

Brick Making.

Firing a Continuous Kiln. Brit Clayworker—Aug., 07. 4 figs. 2800 w. 40c. IX. Natural and Forced Draft.

Cotton-Mill Safety Appliances.

Safety Appliances of Speed-Frames in Cotton Mills. Engg—Aug. 9, 07. 13 figs. 2500 w. 40c.

Gas, Candle-Power Standards for.

The Present Status of Candle-Power Standards for Gas. Am Gas Lt Jl—Aug. 5, 07. 2600 w. 20c. Paper read at the Boston meeting of the Illuminating Engineering Society.

Jute Spinning.

Preparing and Spinning of Jute. D. J. MacDonald. Engg—Aug. 2, 07. 15 figs. 3900 w. 40c. Paper read before the Inst. of Mechanical Engineers at Aberdeen, July 31, discussing present-day practice in jute preparing and spinning.

Paper Manufacture.

The Stoneywood Paper Works. Engr—Aug. 9, 07. 15 figs. 3200 w. 40c. Describes large English plant and the processes employed.

Peat-Fuel Manufacture.

The Manufacture of Peat-Fuel in Michigan. Francis J. Bulask. Power—Sept., 07. 4 figs. 2000 w. 40c. Describes the only "wet process" in use in America from bog to drying sheds, with a brief outline of the industry.

Water Gas.

Water Gas. H. Dicke. Stahl u Eisen—Aug. 14, 07. 10 figs. 4700 w. 60c. Describes the Dellwik-Fleischer system and its uses.

MARINE ENGINEERING

Auxiliary Coasting Schooner.

The Auxiliary Coasting Schooner Northland. Int Mar Engg—Sept., 07. 6 figs. 2000 w. 40c. Describes a large schooner having for an auxiliary engine a 500-HP. six-cylinder double-acting reversing gasoline motor.

Combined Indicator Cards.

Combined Indicator Cards—I. Charles S. Linch. Int Mar Engg—Sept., 07. 5 figs. 3200 w. 40c. Shows a number of combined cards of marine engines in everyday use, and points at their value in detecting faults.

Electrical Equipment of Ships.

The Modern Electrical Equipment of Ships. C. Schulthes. Elek Zeit—Aug. 1, 07. 10 figs. 2500 w. 40c. Aug. 8, 21 figs. 5500 w. 40c.

Electricity on Board Ship. Sydney F. Walker. Mar Eng & Nav Arch—Aug. 1, 07. 1 fig. 2400 w. 40c. XI. Discusses the distribution of the current by the three-wire system.

Gliding Craft.

A Practical Gliding Craft, with Submerged Hydroplanes. Sc Am—Aug. 3, 07. 4 figs. 1500 w. 20c. Describes a boat designed by Peter Cooper Hewitt, the inventor of the mercury-vapor lamp.

High-Speed Two-Stroke Engines.

High-Speed Two-Stroke Engines, with Remarks on Internal Water Cooling. T. D. Kelly. Prac Engr—July 26, 07. 2 figs. 3800 w. 40c. Abstract of a paper read before the Institution of Marine Engineers, March 7, 07.

Indian Liner.

The New Indian Liner, City of London. Benjamin Taylor. Int Mar Engg—Sept., 07. 3 figs. 2800 w. 40c.

Light Single-Screw Passenger Vessels.

Light-Draft Single-Screw Passenger Vessels. Int Mar Engg—Sept., 07. 4 figs. 3200 w. 40c. Gives description of five vessels constructed according to U. S. Government specifications.

Propulsion by Non-Reversible Engines.

The Propulsion of Ships by Means of Non-Reversible Engines. Int Mar Engg—Sept., 07. 4 figs. 3200 w. 40c.

Screw Propellers.

Comparative Study of Screw Propellers. W. Helling. Z V D I—Aug. 24, 07. 4 figs. 2200 w. 60c. Gives results of four designs of screw propeller tests by a Swedish motor-boat builder.

Laying Out a Propeller. J. S. Watts. Machy—Sept., 07. 2 figs. 1400 w. 40c.

The Screw Propeller. A. E. Seaton. Mar Engr & Nav Arch—Aug. 1, 07. 2200 w. 40c.

Submarine Navigation.

The Present and Future of Submarine Navigation. A. M. Laubeuf. Engg—July 26, 07. 3600 w. 40c. From paper read at the Bordeaux International Congress in Naval Architecture.

The "Lusitania."

The Cunard Turbine-Driven Quadruple-Screw Atlantic Liner "Lusitania." Engg—Aug. 2, 07. 80c. Sixty-six pages of this issue (187 illustrations) are given up to an exhaustive description of the engineering features of this new steamship, its accommodations for passengers, etc.

Vibration Recorder.

The Electric Pallograph. Prac Engr—Aug. 16, 07. 4 figs. 2500 w. 40c. Describes an instrument designed by Otto Schlick, of Hamburg, Germany, for measuring and registering the vibrations of steamships.

MECHANICAL ENGINEERING

AIR MACHINERY.

Centrifugal Fan.

High-Pressure Centrifugal Fans. A. Rateau. Engg—Aug. 16, 07. 6 figs. 7500 w. 40c. First part of an article on turbo-fans, with a discussion on the question of efficiency.

Compressor.

A New Development in Air Compressors. Am Mach—Aug. 22, 07. 10 figs. 3000 w. 20c. Describes a machine that at constant speed automatically varies the volume of air delivered to meet the constantly fluctuating demand.

Hammers.

Compressed Air for Steam Hammers. Frank Richards. Comp Air—Aug., 07. 2600 w. Discusses considerations of the economy and expediency of employing compressed air for driving steam hammers.

Heaters, Filters, etc.

Compressed Air Equipment: Heaters, Filters, etc. H. Grimmer. Dingler's Poly Jl—July 20, 07. 7 figs. 1500 w. July 27; 24 figs, 1800 w. Aug. 3, 07. 20 figs. 2000 w. Aug. 10. 21 figs. 2400 w. Each 40c.

Pumping Sand.

Pumping Sand by Compressed Air. Lucius I. Wightman. Comp Air—Aug., 07. 2 figs. 1400 w. 20c.

Pneumatic Tools.

Portable Pneumatic Tools. Herbert Bing. Engg—Aug. 9, 07. 6 figs. 3300 w. Aug. 16. 26 figs. 7400 w. Each, 40c. Describes a number of new hammers and results obtained by their use.

The Economic Significance of Pneumatic Tools. Alex Lang. Z V D I—July 20, 07. 1 fig. 3200 w. 60c.

Turbo-Blowers.

The Parsons Turbo-Blower for Blast Furnaces. Iron Age—Aug. 22, 07. 5 figs. 2000 w. 20c. Describes an installation at the Trzynietz (Brünn) Furnace Plant.

The Parsons Turbine-Blower for Blast Furnace Work. J. Fuerstenau. Z V D I—July 20, 07. 12 figs. 5700 w. 60c.

DRAFTING.

Graphic and Other Aids in Designing. Luther D. Burlingame. Am Mach—Aug. 29, 07. 6 figs. 1800 w. 20c. Describes the use of drawings and samples of various machine parts for the purpose of aiding draftsmen in determining sizes, etc., of component parts of machines.

Mechanical and Electrical Drafting Room Record, Pacific Electric Railway. El Ry Rev—Aug. 24, 07. 5 figs. 1800 w. 20c.

Perspective and Isometric Drawing. Frederick R. Honey. Machy—Aug., 07. 5 figs. 1400 w. 40c. Describes a simple method of drawing machine parts in perspective.

Pointers for Checking Drawings. Am Mach—Aug. 15, 07. 1300 w. 20c.

FOUNDING.

Alloys for Foundry Use.

Aluminum Alloy Founding Practice. Hugh Dolnar. Am Mach—Aug. 22, 07. 8 figs. 3900 w. 20c. Describes the mixtures used and precautions taken to insure sound castings in one of the largest foundries in the country.

Ferro-Alloys for Foundry Use. E. Houghton. Foundry—Sept., 07. 5600 w. 20c. Describes the methods of production and the treatment of iron to secure definite chemical and physical properties.

Blower Casings.

Molding a Vertical Blower Casing. W. W. McCarter. So Mach—Aug., 07. 2200 w. 20c.

Casting Finished Bearings.

Casting Finished Bearings Accurately. Am Mach—Aug. 8, 07. 3 figs. 600 w. 20c.

Chilled Iron Castings.

Chilled Castings in Iron. Walter J. May. Prac Engr—Aug. 2, 07. 6 figs. 1500 w. 40c.

Core Ovens.

Improvements in Core Ovens for Iron and Steel Foundries. Stahl u Eisen—July 24, 07. 3 figs. 3300 w. 60c.

Drying and Annealing Furnaces.

Drying and Annealing Furnaces for Steel Foundries. Mech Wld—July 26, 07. 10 figs. 1000 w. 20c.

Gas-Engine Cylinder.

An Air-Cooled Gas-Engine Cylinder. E. F. Lake. Foundry—Sept., 07. 6 figs. 4600 w. 20c. Describes methods of molding and patternmaking and also the new problems presented to foundrymen by reason of the light weight of automobile castings.

Iron Castings, Failure of.

Iron Castings; Some Causes of Failure in Service. Robert Job. Chem Engr—July, 07. 1500 w. 20c. Read at the Atlantic City meeting of the American Society for Testing Materials, June 20.

Tapering Pipe Bend.

Molding a Tapering Pipe Bend. G. Buchanan. Am Mach—Aug. 22, 07. 3 figs. 1000 w. 20c.

HEATING AND VENTILATION.

Hot-Air Heating.

Design of a Plenum System of Warm-Air Heating for a School or Office Building. J. D. Hoffman. Heat & Vent Mag—Aug., 07. 4 figs. 4400 w. 20c. Paper read before the American Society of Heating and Ventilating Engineers, Milwaukee, July 18-19.

Installation of Warm-Air Furnaces. R. S. Thompson. Met Wkr—Aug. 24, 07. 1000 w. 20c. Paper read before the National Association of Master Sheet Metal Workers, Cleveland, Aug. 14-16.

Humidity, Control of.

Humidity and Its Control. Van Rensselaer H. Greene. Cld Stor & Ice Tr Jl—Aug., 07. 2600 w. 40c.

Steam Heating.

The Combined Pressure and Vacuum System of Steam Heating. George D. Hoffman. Dom Engg—Aug. 3, 07. 3300 w. 20c. Read at the Milwaukee meeting of the American Society of Heating and Ventilating Engineers, July 18-19.

Ventilation.

Air and Its Relation to Vital Energy. S. H. Woodbridge. Dom Engg—Aug. 3, 07. 1700 w. Aug. 24. 1 fig. 3100 w. Each 20c. Aug. 3: Contamination of House Air by Earth, Air and Vapors. Aug. 24: Quantity of Air Required for Ventilation.

Clean Air as a Money Saver. Hugo Diemer. System—Aug., 07. 3 figs. 1400 w. 20c. Describes a method of ventilating and spraying for saving goods from damage from soot and also increasing the efficiency of employees by means of a pure atmosphere.

The Heating and Ventilation of Machine Shops. Chas. L. Hubbard. Machy—Sept., 07. 9 figs. 3900 w. 40c.

The Ventilation of Workshops.—I. Mech Engr—Aug. 17, 07. 4 figs. 5000 w. 40c. Committee report to the British Home Office.

Ventilation and Refrigeration of Ammunition-Holds. Adrien Bochet. Engg—July 26, 07. From a paper read at the Bordeaux International Congress in Naval Architecture, June 27.

HOISTING AND HANDLING MACHINERY.

Cranes.

Electric Power Requirements of Cranes. H. Koll. Dinglers Poly Jl—July 13, 07. 3600 w. 40c. July 20. 6 figs. 1500 w. 40c.

Recent Heavy Cranes in English Shops. Eng News—Aug. 29, 07. 2 figs. 2000 w. 20c.

The Design of Under Carriages for Jib Cranes—I. E. G. Fiegehen. Prac Engr—Aug. 23, 07. 3 figs. 2800 w. 40c.

Coal Storage.

Some Recent Mechanical Coal Storage Plants. Wilbur G. Hudson. Eng News—Aug. 29, 07. 7000 w. 20c.

Elevators.

Elevators. Ind Mag—Aug., 07. 30 figs. 4600 w. 20c. V. Description of Electric Drum Type Elevators.

The Growth and Development of the Elevator Industry. Charles H. Kloman. Cass Mag—Sept., 07. 14 figs. 3200 w. 40c. A review in which important modifications in construction and operation are indicated.

The Hydraulic Elevator. W. Baxter. Power—Sept., 07. 12 figs. 1800 w. 40c. IX. Automatic Devices Used for Stopping Cars at Top and Bottom Landing; Their Care and Their Value as Safety Appliances.

Ore-Handling Plant.

A Cripple Creek Ore-Handling Plant. S. A. Worcester. Eng & Min Jl—Aug. 24, 07. 2 figs. 2000 w. 20c. Describes a single, counter-balanced skip, discharging into self-dumping cars, which adds 33% to the capacity of a shaft.

HYDRAULIC POWER PLANTS.

Centrifugal Pumps.

Centrifugal Pumps. W. O. Webber. Engr—Aug. 1, 07. 10 figs. 2800 w. 20c. Describes various types of pumps and their construction.

Hydro-Electric Plants.

Kern River No. 1 Power Plant of the Edison Electric Company, Los Angeles. El Wld—Aug. 10, 07. 8 figs. 5000 w. Aug. 17. 12 figs. 6300 w. Aug. 24. 9 figs. 4,800 w. Aug. 31. 11 figs. 7300 w. Also Eng Rec—Aug. 10, 07 9 figs. 7600 w. Each 20c.

Power Plant Inside of a Dam on the Patapsco River. El Wld—Aug. 3, 07. 9 figs. 2900 w. 20c. Describes a reinforced-concrete dam 168 ft. long at Ellicott City, Md., having the water wheels and generators located inside.

The Caffaro (Italy) Power Station. Engg—Aug. 9, 07. 1200 w. 40c.

The Hydro-Electric Plant of the Huronian Co. Eng Rec—Aug. 3, 07. 4 figs. 3200 w. 20c. Describes plant for furnishing power to nickel and copper mines in the Sudbury (Canada) districts.

Pumps and Pumping Machinery.

Improvements in the Vertical Plunger Sinking Pump. A. H. Hale. Power—Sept., 07. 4 figs. 1800 w. 40c.

Modern Pumping and Hydraulic Machinery. Edward Butler. Mech Engr—Aug. 3, 07. 7 figs. 3000 w. Aug. 10. 9 figs. 4100 w. Each 40c.

The New Pumping Machinery of the Hamburg Water Works. R. Schroeder. Z V D I—July 27, 07. 11 figs. 6500 w Aug. 3. 30 figs. 1800 w. Each 60c. Concluded.

Two-Stage Operation of a Large Pumping Engine. A. O. Doane. Eng News—Aug. 29, 07. 9 figs. 2000 w. 20c. Describes reserve pumping machinery used by the Met. W. W. of Mass.

Tests of Pumping Plants.

Mechanical Tests of Pumping Plants Used for Irrigation. R. P. Teele. Engr—Sept. 2, 07. 2000 w. 20c. Gives a comparison of gasoline and steam outfits and of centrifugal, reciprocating and air-lift pumps.

INTERNAL-COMBUSTION ENGINES.

Exhaust Gases.

On the Gases Exhausted from a Petrol Motor. B. Hopkinson and L. G. E. Morse. Engg—Aug. 9, 07. 6 figs. 3100 w. 40c.

Gas and Oil Engines, Present Status.

The Present Position of Gas and Petrol Engines. Dugald Clerk. Gas & Oil Power—Aug. 15, 07. 3 figs. 5500 w. 40c. Paper read before the British Association at Leicester, Aug. 1.

Ignition.

Igniters in Gas Engines. R. S. Nelson. Engr—Sept. 2, 07. 800 w.

Large Gas Engines.

Improvements in Large Gas Engines. Dr. Von Handorff. Z V D I—Aug. 17, 07. 23 figs. 5500 w. 60c.

Mains and Fittings.

Mains and Fittings for Gas Power Plants. L. L. Brewer. Power—Sept., 07. 2800 w. 40c.

Six-Cylinder 500-HP. Internal-Combustion Engine. Engg—Aug. 16, 07. 5 figs. 500 w. 40c.

Natural Gas.

Best Methods for Using Natural Gas. C. W. Sears. Prog Age—Aug. 15, 07. 20 figs. 6000 w. 40c. Paper read before the Natural Gas Association of America, Joplin, Mo., May 23.

Gas Engines in the Natural Gas Field. John D. Hackstaff. Prog Age—Aug. 15, 07. 4000 w. 40c. Paper read before the Natural Gas Association of America, Joplin, Mo., May 21-23.

Oil Engines.

Novel High Compression Oil Engine. Alfred G. Gradenwitz. Machy—Sept., 07. 2 figs. 1400 w. 40c. Describes a new German engine having an improved oil atomizer.

Oil Engines. S. M. Howell. Machy—Aug., 07. 7 figs. 2500 w. 40c. Describes several internal-combustion engines using crude oil fuel.

Progress in Oil Engines. E. F. Lake. Engr—Aug. 15, 07. 5 figs. 3200 w. 20c. Shows wherein the oil engine excels the gasoline, its cost of operation and progress on land and sea.

Pressures and Work, Formulas for.

Pressures and Work in a Gas Engine. Cecil P. Poole. Power—Sept., 07. 3000 w. 40c. Gives forty or more formulas for pressures developed by compression, combustion and expansion work, HP., and M. E. P., some of which have not hitherto been published.

Producer Gas.

A Commercial Method of Testing Producer Gas for Sulphur. Randolph Bolling. Eng News—Aug. 1, 07. 1600 w. 20c.

Modern Power Gas Producer Practice and Application. Horace Allen. Prac Engr—Aug. 2, 07. 2400 w. Continued. Power gas installation generally considered.

Testing Producer Gas for Sulphur. Randolph Bolling. Ir Age—Aug. 8, 07. 1 fig. 1100 w. 20c. Sets forth the advantages of a method devised by the author.

Producer Gas Engines.

Producer Gas Engines. F. W. Burger. Engr—Aug. 1, 07. 2 figs. 3000 w. 20c. Enumerates a number of points requiring attention in the design of this type of engine.

MACHINE PARTS.

Ball Bearings.

Designing a Three-Point Ball Bearing. 2 figs. 1000 w. Am Mach—Aug 1, 07. 20c.

The Design and Use of Ball Bearings—I. Henry Hess. Am Mach—Aug. 29, 07. 14 figs. 2100 w. 20c. States how they should be designed by careful computations and from the best of materials; the characteristics of good balls.

Eccentric Pull-and-Push Rods.

The Design of Eccentric Pull-and-Push Rods. H. M. P. Murphy. Am Mach—Aug. 29, 07. 8 figs. 1900 w. 20c.

Epicyclic Wheel Trains.

Calculations Respecting Epicyclic Wheel Trains. W. Owen. Am Mach—Aug. 8, 07. 3 figs. 1600 w. 20c.

Feed Mechanisms.

Feeds and Feed Mechanisms. John Edgar. Mach—Aug., 07. 2 figs. 4400 w. 40c. Discusses their redesign in order to use higher-speed tools to advantage.

High-Pressure Machinery, Design of.

On the Design of Machinery for Very High Pressure. J. E. Petavel. Engg—July 26, 07. 7 figs. 1400 w. 40c. Discusses tube connections, covers for apertures, etc., for use with high pressure.

New German Machine Tool Devices.

Recent advance in German Machine Tool Construction. Fr. Ruppert. Z V D I—Aug. 3, 07. 42 figs. 6500 w. 60c. Describes a number of new devices employed in various machine tools.

Ring-Lubricated Bearings.

Ring-Lubricated Bearings. C. Volk. Z V D I—Aug. 10, 07. 37 figs. 1500 w. 60c.

Turret Lathe Tailstock.

A Multiple-Spindle Tailstock for Turret Work on an Engine Lathe. Oscar E. Perrigo. Am Mach—Aug. 29, 07. 4 figs. 1800 w. 20c.

Worm Gearing.

Calculating the Dimensions of Worm-Gearing. Ralph E. Flanders. Machy—Aug., 07. 5 figs. 3300 w. 40c.

MATERIALS.

Alloys.

Alloys. A. Humboldt Sexton. Mech Engr—Aug. 3, 07. 4 figs. 3000 w. 40c. XXI. Silver Alloys.

Brass and Bronze.

Tests of Some Brass and Bronze Bars. Harry B. de Pont. Foundry—Sept., 07. 2 figs. 3900 w. 20c. Gives results of a series of interesting experiments to ascertain their chemical and physical properties.

Copper.

Corrosion of Copper and Copper Alloys—III. John G. A. Rhodin. Engr—Aug. 2, 07. 2800 w. 40c.

Graphite.

A New Lubricant, the "Acheson Effect," and "Deflocculated Graphite." Edward G. Acheson. Eng News—Aug. 1, 07. 5 figs. 3600 w. 20c. Adapted by the author from a paper presented by him before the American Institute of Electrical Engineers on June 27.

Grinding Wheels.

Efficiency Tests of Wet Emery and Carborundum Wheels. G. Schlesinger. Z V D I—Aug. 3, 07. 7 figs. 1800 w. 60c.

Iron for Cylinders.

Experiments with Cylinder Irons. Ir & Cl Tr Rev—Aug. 9, 07. 2000 w. 40c. Abstract of paper read by R. Buchanan before the Cleveland Institute of Engineers.

Lubricants, Tests of.

Baumé Hydrometer Charts. R. S. King. Engr—Sept. 2, 07. 2 figs. 2000 w. 20c. Gives charts for use in testing of oils and brines by specific gravity.

Malleable Cast Iron.

Malleable Castings. E. L. Rhead. Mech Engr—Aug. 3, 07. 3 figs. 5200 w. 40c. First of a series of articles on their manufacture and properties.

Nickel Steel.

Nickel Steel. E. F. Lake. Machy—Sept., 07. 3900 w. 40c.

Testing Machine.

An Electrically Controlled Single Lever Testing Machine and Some Torsion Tests. Charles E. Larard. Engr—Aug. 2, 07. 9 figs. 5200 w. Aug. 9. 21 figs. 2800 w. Each, 40c. Paper read at the Aberdeen meeting of the Inst. of Mechanical Engineers, July 18.

MECHANICS.

Balancing.

Cream Separator Bowl Balancing. Machy—Sept., 07. 2 figs. 1400 w. 40c. Describes method used in balancing the rotating part so that it will run to full speed or beyond without producing any perceptible vibration in any part of the machine in any period of acceleration or falling-off of speed.

The Balancing of Rapidly Rotating Machine Parts. Monitz Kroll. Elek u Masch—July 28, 07. 5 figs. 2700 w. 60c.

Chains, Strength of.

Strength of Chains. N. A. Carle. Power—Sept., 07. 1 diagram. 500 w. 40c. Gives a chart based on a table from "Kent."

Energy of the Universe.

The Energy Problem of the Universe. A. H. Gibson. Cass Mag—Sept., 07. 5600 w. 40c.

Flow of Fluids in Thin Annular Columns.

The Flow of Gases and Liquids in Thin Annular Columns. E. Becker. Z V D I—July 20, 07. 12 figs. 7700 w. 60c.

Flow Through Orifices.

The Flow of Liquids Through Orifices of Unusual Form. Zeit d Oest Ing u Arch—Aug. 9, 07. 10 figs. 3900 w. 60c.

Friction of Packing Rings.

The Friction of Packing Rings. A. Martens. Z V D I—July 27, 07. 5 figs. 1200 w. 60c.

Graphics.

Reciprocal Methods for Problems Soluble by Means of Force Polygons. R. Kafka. Zeit Oest Ing u Arch—Aug. 23, 07. 14 figs. 3500 w. 60c.

Gyroscope.

The Gyroscope. C. M. Broomall. Sc Am Supp—Aug. 10, 07. 4 figs. 3900 w. 20c. Gives an explanation of the action of the gyroscope in everyday language and free from mathematics.

High-Speed Disk Stresses.

Stresses in Rapidly Rotating Disk Wheels. A. Stodola. Z V D I—Aug. 31, 07. 6 figs. 5000 w. 60c.

Power Transmitting Device.

A Device for Transmitting Power Between Two Inclined Shafts by Means of a Straight Belt. Am Mach—Aug. 1, 07. 3 figs. 900 w. 20c.

Recoil.

The Dynamics of Long Recoil. A. G. Greenhill. Engr—Aug. 23, 07. 3 figs. 2500 w. 40c. Describes the mechanical principles involved in the use of a long recoil on carriages of field guns for preventing wheels from jumping off the ground.

Rupture.

Rupture Through Expansion by Heat. C. Sulzer. Z V D I—July 27, 07. 15 figs. 3500 w. 60c. Discusses the rupture of boiler sheets, rivets, etc.

Scales.

Heavy Weighing Scales: The Influence of Deflection on the Beam Ratios; Tests with Partly Unknown Loads. J. Zingler. Zeit d Oest Ing u Arch—Aug. 2, 07. 4 figs. 4000 w. 60c.

Tube-Connected Cylinders.

Tests of Tube-Connected Cylinders. S. F. Jeter. Power—Sept., 07. 8 figs. 1600 w. 40c. Describes a test of two bumped-headed boiler-plate drums, connected by tubes.

METAL WORKING.

Annealing.

Annealing High-Speed Steel. Ethan Viall. Am Mach—Aug. 29, 07. 1 fig. 1600 w. 20c.

Small Furnace for Special Work. F. H. Neely. Am Mach—Aug. 8, 07. 3 figs. 900 w. 20c.

Boring Mill.

Work of the Floor-Plate Boring Mill. Am Mach—Aug. 15, 07. 4 figs. 1100 w. 20c. Gives illustrations of original shop methods showing the wide range and flexibility of a novel home-made tool.

Cams.

Notes on Cam Design and Cam Cutting. James L. Dinnany. Machy—Aug., 07. 4 figs. 2800 w. 40c.

Simplifying a Difficult Cam Job. Am Mach—Aug. 1, 07. 3 figs. 2500 w. 20c.

Case-Hardening.

Case-Hardening the Alloy Steeels. E. F. Lake. Am Mach—Aug. 8, 07. 4000 w. 20c. Gives instructions for selecting the best alloys, the proper carbonizing materials and for the correct heat treatment to secure satisfactory results.

Dial-Measuring Machine.

Making a Dial-Measuring Machine. Oscar E. Perrigo. Am Mach—Aug. 15, 07. 6 figs. 2600 w. 20c.

Files, Manufacture of.

Making Swiss Files in America—I. Machy—Sept., 07. 6 figs. 3900 w. 40c. Describes plant and processes of the Am. Swiss File & Tool Co.

Flanging.

A Large Hydraulic Flanging Press. E. A. Dixie. Am Mach—Aug. 15, 07. 10 figs. 2600 w. 20c. Describes how the flanged work for the P. R. R. system is produced by the use of a hydraulic press and cast-iron dies.

Forging.

Forging a Lathe Boring Tool. J. F. Sallows. Machy—Sept., 07. 6 figs. 1000 w. 40c.

The Forging of Alloy Steels. E. F. Lake. Am Mach—Aug. 29, 07. 3600 w. 20c. Shows the effect of temperature, methods of forging, welding and annealing on the production of high-grade forgings.

Grinding.

Speeds on the Grinding Machine. H. F. Noyes. Am Mach—Aug. 22, 07. 2700 w. 20c.

Needle Making.

Automatic Needle-Making Machinery. Machy—Aug., 07. 7 figs. 1500 w. 40c.

Presswork.

Dies for Making Square Pans. Julius F. A. Vogt. Am Mach—Aug. 22, 07. 2000 w. 20c.

Making a Sub-Press Die. H. M. Hyatt. Am Mach—Aug. 22, 07. 1 fig. 1600 w. 20c.

Reamers.

Reamers. Eric Oberg. Machy—Aug., 07. 5 figs. 3500 w. Sept. 4 figs. 2600 w. Each 40c.

Splicing Wire Cables.

Splicing Wire Cables. Florio Seperak. Min Rep—Aug., 07. 3 figs. 1000 w. 20c.

Welding.

Autogenous Welding. F. C. Cutler. Cass Mag—Sept., 07. 9 figs. 2800 w. 40c.

Wire Drawing.

Modern Practice in Wire-Drawing Machines.—I. Engg—Aug. 9, 07. 5 figs. 1800 w. 40c. First of a series on the trend in the design of machines used for all classes of wire-making.

Worm Gears.

Machining a Bronze Worm Wheel. Philip G. Hall. Mech Wld—July 26, 07. 10 figs. 2600 w. 20c.

Hobs for Worm Gears. John Edgar. Machy—Sept., 07. 4 figs. 2000 w. 40c.

REFRIGERATION.

Cooling Plant of a Chocolate Mill. Cld Stor & Ice Tr Jl—Aug., 07. 10 figs. 3500 w. 40c. Describes the refrigerator installation of the Walter Baker & Co. factory, Dorchester, Mass.

SHOPS AND BUILDINGS.

Oerlikon Works.

The Oerlikon Works. Engr—Aug. 23, 07. 12 figs. 1600 w. 40c. Illustrated description of this large Swiss engineering works.

Modern Works Practice.

Notes on Modern Engineering Works. R. D. Summerfield. Mech Engr—Aug. 17, 07. 5300 w. 40c. Gives a general sketch of modern practice as regards buildings, equipment and management.

Storage.

Storage in a Large Concrete Machine Shop. L. P. Alford. Am Mach—Aug. 8, 07. 23 figs. 8000 w. 20c. Describes the fire-resisting racks, boxes and other storage devices in the plant of the United Shoe Machinery Company, at Beverly, Mass.

STEAM POWER PLANTS.

Aeration of Steam.

The "Field-Morris" System of the Aeration of Steam. F. A. Lart. Eng Rev—Aug., 07. 4 figs. 3700 w. 40c. Describes a system consisting simply in mixing a suitable proportion of ordinary air compressed to the working boiler pressure with the steam immediately after it leaves the boiler and superheating the mixture thus formed by economical means, such as the waste boiler gases.

Boiler Arches.

Arch Tubes and Brick Arches. Boiler Maker—Aug., 07. 1600 w. 20c.

Boiler and Engine Testing.

Boiler, Engine and Generator Testing and Management. Charles L. Hubbard. El Rev—Aug. 3, 07. 14 figs. 4000 w. Aug. 10, 4000 w. Aug. 17, 3 figs. 3000 w. Aug. 24, 2 figs. 2000 w. Each 20c. Aug. 3: Engine testing. Aug. 10: Management of engines and generators. Aug. 17: Valve-setting. Aug. 24: Valve testing.

Boiler Fittings.

The Piping and Fittings for a Tubular Boiler.—I. F. C. Douglas Wilkes. Boiler Maker—Aug., 07. 6 figs. 5300 w. 20c. Serial—Gives data for the calculation of the various parts.

Pipings and Fittings for a Tubular Boiler. F. C. Douglas Wilkes. Boiler Maker—Sept., 07. 16 figs. 1200 w. 20c.

Boiler-Room Design.

Boiler-Room Design and Equipment. Wm. H. Bryan. Cass Mag—Sept., 07. 8 figs. 5200 w. 40c.

Coal Testing.

Recent Testing of Coal. J. A. Holmes. Mines & Min—Aug., 07. 1 fig. 2400 w. 40c. Describes the methods of sampling at mines and on cars used by the federal government in its public buildings at Washington, D. C.

The Choice of Bituminous Coal. R. H. Kuss. Eng Rec—Aug. 31, 07. 3 figs. 3300 w. 20c.

The Fuel-Testing Plant of the United States Geological Survey at the Jamestown Exposition. El Wld—Aug. 17, 07. 6 figs. 1400 w. 20c.

Comparative Power Costs.

Comparative Costs of Gasoline, Steam and Electricity for Small Powers. William O. Webber. Eng News—Aug. 15, 07. 2500 w. 20c. Gives diagram showing costs per B. HP. per year up to 30 HP.

Relative Economy of Steam and Gas Power where Exhaust Steam is used for Heating. F. W. Ballard. Eng News—Aug. 15, 07. 5000 w. 20c.

The Comparative Cost of Steam and Hydro-Electric Power. W. O. Webber. Eng Mag—Sept., 07. 2200 w. 40c.

Crude Oil Fuel Test.

Test of Power Plant of Home Gas Company, Redlands, Cal. W. F. Durand. Engr—Sept. 2, 07. 10 figs. 5200 w. 20c. Gives details of test of plant using crude oil fuel.

Flash Boilers.

The Flash Steam Generator. H. W. Bolsover. Cass Mag—Sept., 07. 7 figs. 2800 w. 40c. Discussion with particular reference to its use in automobiles.

Governor.

Some Peculiarities of the Rites Governor. S. H. Bunnell. Engr—Sept. 2, 07. 3 figs. 2000 w. 20c. Discusses the queer actions sometimes found, the causes and prevention.

Natural Gas.

Combustion of Natural Gas. E. H. S. Bailey. Prog Age—Aug. 15, 07. 1700 w. Paper read before the Natural Gas Association of America, Joplin, Mo., May 23.

Piping.

Piping Specifications for Superheated Steam Service. Engr—Aug. 15, 07. 1700 w. 20c. Compiled by Crane & Co., Chicago, for steam pressures of 250 lbs. and superheats up to 200° F.

Standard Methods in Pipe Fitting. G. L. Vincent. Prog Age—Aug. 1, 07. 9 figs. 6000 w. 20c. Read before the Iowa District Gas Assn., Cedar Rapids, June 12-13.

Power Plants.

A Progressive Suburban Central Station at Revere, Mass. El Wld—Aug. 3, 07. 5 figs. 300 w. 20c. Describes an interesting example of a central station under unique conditions with respect to load requirements in a suburban territory.

Blue Island Power Station of the North Shore Electric Company of Illinois. W. Elecn—Aug. 24, 07. 9 figs. 4700 w. 20c.

Cos Cob Power Station of the New York. New Haven & Hartford Railroad Co. El Wld—Aug. 23, 07. 8 figs. 5800 w. 20c.

Mechanical Plant of the New City Hall at Newark, New Jersey.—II. Eng Rec—Aug. 24, 07. 3 figs. 1900 w. 20c.

Pressure Gages.

History and Construction of Pressure Gages.—I. C. E. Stromeyer. Mech Engr—Aug., 07. 2 figs. 4400 w. 20c.

Saturated Steam.

Physical Properties of Saturated Steam. Fred R. Low. Power—Sept., 07. 5 figs. 5500 w. 40c. A simple explanation of the steam tables; why temperature varies with the pressure, and what is meant by latent heat, saturated steam, etc.

Smoke Abatement.

Advantages of Mechanical Stokers as Smoke Abaters. Paul M. Chamberlain. Ind Wld—Aug. 5, 07. 8 figs. 5000 w. 20c. Lecture before the International Association for the Prevention of Smoke, Milwaukee, Wis.

Steam Turbines.

Best Method of Supplying Oil to Turbines. Thomas Franklin. Power—Sept., 07. 4 figs. 2800 w. 40c. Discusses the isolated oil-filtering and cooling plant and states its advantages and points to be looked to in its design and operation.

The Melms-Pfenninger Combined Impulse and Reaction Turbine. R. Stresau. Power—Sept., 07. 6 figs. 2400 w. 40c. Gives particulars of a new turbine manufactured in Munich.

The Modern Steam Turbine. Arnold F. Harrison. Ir & Cl Tr Rev—Aug. 9, 07. 11 figs. 3500 w. 40c. Paper describing recent types of turbines, read before the Manchester Assn. of Students of the Inst. C. E.

The Reliability of Steam Turbine and Turbo-Generators in Practical Service. F. Niethammer. Elek u Masch—July 21, 07. 11 figs. 5500 w. July 28, 5 figs. 4500 w. Each 60c.

Steel Stack Design.

The Layout and Construction of Steel Stacks. Boiler Maker—Aug., 07. 12 figs. 4200 w. 20c.

Superheated Steam.

The Latest Research on the Specific Heat of Superheated Steam. Robert H. Smith. Engr—Aug. 23, 07. 5 figs. 3000 w. 40c. Gives diagrams embodying the results obtained by Knoblauch and Jakob for facilitating their use.

WOODWORKING.

Pattern-Making.

Disk Patterns for a Centrifugal Pump. Jno. J. Atkinson. Wood Craft—Sept., 07. 600 w. 20c.

Pattern for Gas Engine Fly Wheel. T. E. O'Donnell. Foundry—Sept., 07. 4 figs. 800 w. 20c.

Patternmaking and Core Boxes. C. E. McGahey. Wood Craft—Aug., 07. 2000 w. 20c. Describes the methods found most profitable in a plant mainly engaged in the building of steam engines.

Patterns for Steel Castings. H. J. McCaslin. Wood Craft—Sept., 07. 4 figs. 600 w. 20c.

Patterns to Suit the Foundryman. Oscar E. Perrigo. Foundry—Sept., 07. 8 figs. 3600 w. 20c. Gives a number of illustrations in actual shop practice of the good results attained by pursuing this course.

The Pattern-Making of Locomotive Cylinder. J. W. Wolfenden. Am Mach—Aug. 15, 07. 17 figs. 1500 w. 20c.

Planes and Molder Knives.

Laying Out Molder Knives. W. D. Graves. Wood Craft—Aug., 07. 5 figs. 1400 w. 20c. Gives method and illustrations of its application.

Sharpening Planer-Knives. James F. Hobart. Wood Craft—Aug., 07. 5 figs. 2400 w. 20c.

Rolls for Textile Machinery.

Making Wooden Rolls for Textile Machinery. G. A. Dexter. Am Mach—Aug. 8, 07. 8 figs. 1000 w. 20c.

Wood Bending.

Pointers on Wood Bending. L. Kay. Wood Craft—Aug., 07. 2000 w. 20c. Discusses selection of wood and compression, preparing the stock, the use of steam, etc.

Wood Finishing.

Wood Finishing. A. Ashmun Kelly. Wood Craft—Aug., 07. 3000 w. 20c. Describes the use of aniline stains on woods and the finishing of birch, giving approved practice in each.

Wood Finishing Practice. A. Ashmun Kelly. Wood Craft—Sept., 07. 2800 w. 20c. Discusses the surfaces of pianos, the preservation of brushes, the care of materials, and gives data on finishes, stains of vegetables and other useful information.

METALLURGY

Alloy Steels.

Heat Treatment of Alloyed Steel. E. F. Lake. Am Mach—Aug. 1, 07. 5500 w. 20c. Discusses methods of annealing, temperatures which are safe, ways of heating and quenching and effect of various alloys.

Taylor's Investigation on High-Speed Steel. A. Wallichs and O. Peterson. Stahl u Eisen—July 24, 07. 2 figs. 4300 w. 60c.

The Present State of Our Knowledge regarding the Cooling and Freezing Conditions of Carbon-Iron Alloys. P. Goerens. Stahl u Eisen—July 24, 07. 10 figs. 5200 w. 60c.

Blast Furnaces.

Charging a Modern Iron Blast Furnace. Bradley Stoughton. Eng & Min Jl. 2100 w. 20c. States how the ore flux and fuel charged in a blast furnace can be adjusted to produce definite results in the output.

The Blast Furnace.—VI. Horace Allen. Ir Tr Rev—Aug. 8, 07. 1600 w. 20c. Describes the use of slag for cement manufacture.

The Chemistry of the Iron Blast Furnace. Bradley Stoughton. Eng & Min Jl—Aug. 3, 07. 2 figs. 2400 w. 20c. Describes the successive chemical reactions which occur during the reduction of iron ore to pig iron in the blast furnace.

The Operation of the Iron Blast Furnace. Bradley Stoughton. Eng & Min Jl—Aug. 17, 07. 2 figs. 2800 w. 20c. Gives details of the working of a blast furnace and of a disposition of the iron and the slag.

Coke.

The Manufacture of Coke from Western Coal. R. S. Moss. Min Wld—Aug. 17, 07. 3 figs. 2400 w. 20c.

Why Is It That Some Coals Coke and Others Do Not? F. C. Keighley. Ir Age—Aug. 8, 07. 3300 w. 20c. From the presidential address at the Pittsburg meeting of the Coal Mining Institute of America, June, 1907.

Copper.

Notes on Copper. A. Humboldt Sexton. Mech Engr—July 27, 07. 1 diagram. 2800 w. 40c. IV.—Reduction of the copper from the rich regulus.

Notes on Copper. A. Humboldt Sexton. Mech Engr—Aug. 10, 07. 3 figs. 6000 w. 40c. V. The Welsh copper process.

Gold.

The Black Sand Problem. F. Powell. Eng & Min Jl—Aug. 10, 07. 2 figs. 2200 w. 20c. Notes on the preliminary concentration of auriferous black sand.

The Volatization of Gold During Melting. Dr. T. Kirk Rose. Eng & Min Jl—Aug. 17, 07. 700 w. 20c. From the annual report (1906) of the Royal Mint.

Laboratory Furnaces.

Laboratory Crucible and Muffle Furnace. George T. Holloway. Min Wld—Aug. 3, 07. 2 figs. 4200 w. 20c.

Lead Refining.

The Refining of Lead. Lincoln Burrows. Met Ind—Aug., 07. 3 figs. 2700 w. 20c.

The Betts Process at Trail, B. C. A. G. Wolf. Mines & Minerals—Aug., 07. 5 figs. 6000 w. 40c. Describes the Betts patented process for the electrolytic refining of lead bullion, treatment of gold and silver slimes and copper sulphate recovery.

Mercury.

The Use and Care of Mercury. Min & Sc Pr—Aug. 17, 07. 2800 w. 20c.

Metallurgical Calculations.

Calculation of Furnace Charges. Regis Chauvenet. Min Rep—Aug. 8, 07. 3300 w. Aug. 15. 4300 w. Aug. 22. 2600 w. Each 20c.

Use of Graphic Formulae in Metallurgical Calculations. David H. Browne. Min Wld—Aug. 3, 07. 500 w. 20c. Abstract of paper read at Toronto meeting, Can. Mg. Inst., March, 1907.

Metallurgical Vagaries.

Some Metallurgical Vagaries and the Results. Dwight E. Woodbridge. Eng & Min Jl—Aug. 10, 07. 1 fig. 1600 w. 20c. Describes unsuccessful attempts to apply certain wild theories of ore treatment and smelting.

Rolling Mills.

Electric Equipment of Reversing Rolling Mills. H. Alexander. Elek Zeit—July 25, 07. 3 figs. 1800 w. 40c.

New Continuous Merchant Bar Rolling Mill. Stahl und Eisen—Aug. 14, 07. 5 figs. 1600 w. 60c.

Slags.

Acid Open-Hearth Slag. W. M. Carr. Foundry—Sept., 07. 1000 w. 20c.

The Phyisco-Chemical Ratio of Blast Furnace Slags and Cements. K. Zilkowski. Stahl und Eisen—July 24, 07. 5200 w. 60c.

Smelting.

Briton Ferry Works of the Cape Copper Co. Edward Walker. Eng & Min Jl—Aug. 17, 07. 5 figs. 1600 w. 20c. Describes works in South Wales where African ores are calcined in cylindrical and mechanically rabbled furnaces, and smelted in reverberatories.

Modern Method of Calcining Iron Ore. Arthur E. Pratt. Min Wld—Aug. 24, 07. 1800 w. 20c.

Negative Results in Pyritic Smelting. G. F. Beardsley. Eng & Min Jl—Aug. 24, 07. 1800 w. 20c. Describes an interesting though unsuccessful attempt at pyritic smelting of copper-nickel ores.

The Largest Copper Smelting Plant in the World. Eng News—Aug. 1, 07. 2 figs. 3700 w. 20c.

The Mining & Smelting Equipment of the Canadian Copper Company. David H. Browne. Can Min Jl—Aug. 1, 07. 13 figs. 6400 w. 40c.

The Washoe Smelter. Mines & Min—Aug., 07. 3 figs. 6000 w. 40c. Gives a brief description, showing buildings, equipment, processes used and methods of handling material.

Stamp.

The Nordberg Compound Steam Stamp. Eng & Min Jl. 4 figs. 4000 w. 20c. Describes steeple-compound steam stamps used in the Lake Superior Copper District and gives the relative economy of simple and compound types.

Steel.

Compression of Steel by Wire Drawing During Solidification in the Ingot Mold. Ir Tr Rev—Aug. 22, 07. 25 figs. 6400 w. 20c. An extended abstract of a monograph by Major E. L. Zalinski, U. S. A. (contributed to the Journal of the U. S. Artillery) describing the Harmet process.

Ingot Heating Apparatus. Engr—Aug. 9, 07. 4 figs. 1400 w. 40c. Describes methods used for large ingots at Sterkrade, Germany.

Methods of Avoiding Piping in Steel Ingots. Adalbert Obholzer. Stahl und Eisen —July 31, 07. 6 figs. 4300 w. 60c.

The Methods Adopted in the Hungarian Government Steel Works, at Diosgyor, for Avoiding Piping in Steel Ingots. Ad. Obholzer. Ir & Cl Tr Rev—Aug. 9, 07. 9 figs. 3000 w. 40c.

The Spark Method for Grading Steels. Albert F. Shore. Am Mach—Aug. 15, 07. 2 figs. 1300 w. 20c.

Treatment of Waste.

The Systematic Treatment of Metalliferous Waste. L. Parry. Min Jl—July 27, 07. 3000 w. Aug. 3. 7500 w. Each 40c. Discusses the smelting of lead and tin ashes and antimonial material.

Zinc.

The Treatment of Zinc Ores. Prof. F. W. Traphagen. Mines & Minerals—Aug., 07. 1 fig. 3000 w. 40c. Discusses wet, magnetic and oil concentration, electrostatic separation, smelting and chemical methods.

MINING ENGINEERING

Blowpipe Tests.

Economic Geology and Mineral Deposits. —XIV. Francis C. Nicholas. Min Wld—Aug. 3, 07. 3700 w. 20c. Gives table of blow-pipe and other tests with instructions.

Coal.

A Mine Dam to Recover Flooded Workings. John H. Haerter. Eng & Min Jl—Aug. 17, 07. 4 figs. 2800 w. 20c. Describes methods of overcoming difficulties in construction at the Buck Run Coal Co.'s colliery, near Minersville, Pa.

Bituminous Coal Washing. G. R. Delamater. Mines & Min—Aug., 07. 7000 w. 40c. Discusses theories and principles and gives efficiency formulas.

New Supplies of Anthracite Coal. W. E. Joyce. Eng & Min Jl—Aug. 3, 07. 2200 w. 20c. States that recent discoveries in Pennsylvania upset established geological theories and point to the existence of coal-seams in unexpected locations.

Rack-Rail Haulage in Coal Mines. George Lynch. Eng & Min Jl—Aug. 3, 07. 6 figs. 4000 w. 20c. Describes methods for supplementing ordinary traction where steep grades occur in mines.

The Baggeridge Colliery. Mines & Minerals—Aug., 07. 2 figs. 3600 w. 40c. Gives an account of the development of a new area of the thick coal of Staffordshire, England.

The Purchase of Coal Under Specification. J. E. Woodwell. Ir Tr Rev—Aug. 22, 07. 5000 w. 20c. Abstract of a paper presented at the Atlantic City (May, 07) meeting of the American Society for Testing Materials.

The Ultimate Crushing Strength of Coal. Joseph Daniels and L. D. Moore. Eng & Min Jl—Aug. 10, 07. 6 figs. 4200 w. 20c. Describes methods used to determine the resisting power of anthracite and bituminous coals and gives the results obtained.

Variability of Coal Seams. Arthur Lakes. Min Wld—Aug. 3, 07. 1000 w. 20c.

Copper.

Mining in the Boundary Copper Field, British Columbia. Ralph Stokes. Min Wld—Aug. 3, 07. 5 figs. 5000 w. 20c.

The Marble Bay Copper Deposit. O. E. Leroy. Min Wld—Aug. 17, 07. 2700 w. 20c.

Corundum.

Corundum at Craigmont, Ont. H. E. T. Haultain. Can Min Jl—Aug. 1, 07. 3 figs. 3900 w. 40c.

Gold.

Gold Mining in Egypt. C. S. Herzig. Min & Sc Pr—Aug. 17, 07. 5 figs. 5300 w. 20c.

Notes on Hydraulic Mining. Mines & Minerals—Aug., 07. 6 figs. 5300 w. 40c. Discusses the subject with special reference to the Cariboo District, British Columbia and Yukon Territory.

Operations and Processes at the De Beers Consolidated Mines. Eng News—Aug. 8, 07. 4 figs. 1800 w. 20c.

Working Costs on the Rand and Comparisons with Mines in California. Ross E. Browne. Min & Sc Pr—July 27, 07. 3 figs. 3900 w. 20c. Abstract of a paper read before the South African Association of Engineers, June 1.

Iron.

Mining Methods on the Gogebic Iron Range. Reginald Meeks. Eng & Min Jl—Aug. 10, 07. 4 figs. 4800 w. 20c. Describes the steel shafts and head frames used.

The Iron Ore Mines of the Mesabi Range. Reginald Meeks. Eng & Min Jl—Aug. 3, 07. 8 figs. 3000 w. 20c.

Nickel.

Microscopical Examination of Nickeliferous Pyrrhotites. William Campbell and Cyril W. Knight. Min Wld—Aug. 3. 07. 2900 w. 20c. Abstract of paper read at Toronto meeting, Can. Mg. Inst., March, 1907.

Ore Deposits.

Lodes in the Tertiary Eruptives of Colorado. T. A. Rickard. Min & Sc Press—Aug. 10, 07. 3 figs. 2400 w. 20c.

Ore Deposits in Serpentine. William Forstner. Min & Sc Pr—July 27, 07. 2300 w. 20c.

The Relation of Ore-Deposition to Physical Conditions. Waldemar Lindgren. Min & Sc Pr—Aug. 17, 07. 4800 w. 20c.

Placer Mining.

The Essential Date of Placer Investigations. J. P. Hutchins. Eng & Min Jl—Aug. 24, 07. 3 figs. 3900 w. 20c.

The Nomenclature of Modern Placer Mining. J. P. Hutchins. Eng & Min Jl—Aug. 17, 07. 4 figs. 2800 w. 20c. Describes the numerous classifications of placers, and the origin of placers and methods of exploitation.

Prospecting.

Practical Points for Prospectors. Matt W. Alderson. Min Wld—Aug. 3, 07. 1700 w. Aug. 10. 3000 w. Each 20c.

Quarrying.

A Machine for Stripping Rock and Ore Bodies. Eng-Contr—July 31, 07. 1 fig. 1400 w. 20c.

Granite Quarrying in Aberdeenshire. William Simpson. Engg—Aug. 2, 07. 11 figs. 4000 w. Aug. 9. 7 figs. 2200 w. Each 40c. Paper read before the Inst. of Mechanical Engineers at Aberdeen, July 30th; discussing the machinery and methods employed.

Shaft Sinking.

Sinking Through Bad Ground. F. W. Adgate. Min & Sc Press—Aug. 10, 07. 2600 w. 20c.

Silver.

The Cobalt Silver Field as an Industry. Ralph Stokes. Min Wld—Aug. 24, 07. 7 figs. 3600 w. 20c.

The Daly-Judge Mine and Mill. Paul A. Gow, Andrew M. Howat, George S. Kruger and F. H. Parsons. Mines & Minerals—Aug., 07. 4 figs. 6000 w. 40c. Gives a description of the veins, methods of working, timbering and figures as to production. From a graduation thesis submitted to the Colorado School of Mines.

Vein Formation at Cobalt, Ontario. J. B. Tyrrell. Can Min Jl—Aug. 1, 07. 3 figs. 2400 w. 40c.

Subsidence.

Subsidence in Underground Mines. Alexander Richardson. Eng & Min Jl—Aug. 3, 07. 7 figs. 5700 w. 20c. A summary of investigations upon certain problems in mining that heretofore have been little discussed.

Zinc.

Ground Breaking in the Joplin District. Doss Brittain. Eng & Min Jl—Aug. 10, 07. 6 figs. 3700 w. 20c.

Open-pit Zinc Mine at Webb City, Mo. F. Lynwood Garrison. Eng & Min Jl—Aug. 17, 07. 11 figs. 900 w. 20c.

MUNICIPAL ENGINEERING

ROADS.

Asphalt Pavement.

The Asphalt Pavement on the Thames Embankment. Eng Rec—Aug. 24, 07. 5 figs. 1100 w. 20c.

Brick Paving.

Cement Filler for Brick Pavements. Mun Engg—Aug., 07. 3 figs. 2500 w. 20c. Gives the requirements for the best known construction which are embodied in specifications approved by the Nat. Brick Mfrs. Assn.

Paving Materials of the Future.

Will the Paving Material of the Present be Used in the Construction of the Pavements of the Future? George W. Tillson. Eng News—Aug. 1, 07. 1600 w. 20c. Opening of an informal discussion on pavements at the annual convention of the American Society of Civil Engineers, July 10.

Roadside Trees.

The King's Highway. Reginald Ryves. Surv—Aug. 9, 07. 4 figs. 5300 w. 40c. XV. The Roadside Trees.

Suburban Roads.

Sanitary Construction and Maintenance of Suburban Roads. Geo. W. Chilyers. Surv—Aug. 23, 07. Paper read lately at Margate before the Institute of Sanitary Engineers.

Wind and Snow, Effects of.

The King's Highway. Reginald Ryves. Surv—Aug. 23, 07. 6 figs. 5200 w. 40c. The effects of wind and snow. Conclusion of series.

SEWERAGE.

Filters.

Sewage Experiments at Matunga, Bombay. Gilbert J. Fowler. Eng News—Aug. 8, 07. 2 figs. 2000 w. 20c.

Sewage Filters Compared. Mun Jl & Engr—Aug. 14, 07. 3300 w. 20c. Discusses the comparative disposition of organic matter by sand, contact and sprinkling filters, giving results obtained at Lawrence, Birmingham and Leeds.

The Use and Abuse of Sewage Purification Plants. A. Elliott Kimberly. Eng Rec—Aug. 31, 07. 5800 w. 20c. Paper read before the Ohio Engineering Society.

Work at the Madeline Sewage Experiment Station, Pasteur Institute of Lille, France. Earle B. Phelps. Eng News—Aug. 15, 07. 2300 w. 20c. Describes results obtained in experiments with contact beds and trickling filters.

River Flushing Plants.

River Flushing Plants at Milwaukee, Wis. Eng News—Aug. 1, 07. 6 figs. 3000 w. 20c.

Sanitary Code, Montclair, N. J.

The Revised Sanitary Code of the Town of Montclair, N. J. Eng News—Aug. 22, 07. 14,700 w. 20c. Gives text of a code evolved during the last 12 years by a succession of expert sanitary engineers.

Sewage Pumping Station, Chicago.

Chicago's Thirty-Ninth Street Sewage Pumping Station. Engr—Aug. 1, 07. 18 figs. 7600 w. 20c. Describes a new plant with a capacity for handling 1,500,000 gals. of sewage and lake water per min.

Sewerage of Buildings.

Roughing-In Plumbing in Buildings. Jno. K. Allen. Dom Engg—Aug. 3, 07. 1 fig. 1200 w. Aug. 17. 1 fig. 3100 w. Each 20c. Aug. 3: Describes packing of joints, the use and cost of tile pipes, etc. Aug. 17: Sewer tests.

The Sanitary Sewerage of Buildings. Thomas S. Ainge. Dom Engg—Aug. 10, 07. 3 figs. 2400 w. Aug. 24. 3 figs. 2200 w. Each 20c. Fifth and sixth installments, dealing with toilet rooms.

Sewer Construction.

Constructing a Sewer Under the Brooklyn Subway. Eng Rec—Aug. 31, 07. 6 figs. 3300 w. 20c.

Trade Wastes, Disposal of.

Report on the Disposal of Trade Wastes of Reading, Pa. Eng News—Aug. 22, 07. 2 figs. 1120 w. 20c.

WATER SUPPLY.

Artesian Supplies.

Water Supplies by Means of Artesian Bored Tube Wells.—I. Herbert F. Broadhurst. Water—Aug. 15, 07. 300 w. 40c. From a paper read before the Institute of Mining Engineers at the London meeting, 1907.

Capacity of Pumping Engines, Increasing.

Increasing the Capacity of Old Water-Works Pumping Engines. A. P. Blackstead. Eng News—Aug. 1, 07. 1 fig. 600 w. 20c.

Cleaning Water Mains.

Cleaning an 8-in. Cast Iron Water Main in Pittsburg, Pa. J. D. Underwood. Eng News—Aug. 15, 07. 2 figs. 1500 w. 20c.

Dams and Reservoirs in America.

Water-works Construction in America. Ernest R. Matthews. Water—Aug. 15, 07. 5 figs. 2600 w. 40c. Describes a number of American reservoirs and dams.

Filter Experiments.

Experiments with a Jewell Filter at the Posen Water Works. E. A. Giesler. Eng Rec—Aug. 10, 07. 3000 w. 20c.

Flexible Water Pipe.

Armored Flexible Water Pipe for Subaqueous Conduit. Eng News—Aug. 22, 07. 1 fig. 700 w. 20c.

Ground-Water Supply.

A Study of Ground-Water Supply. Eng Rec—Aug. 3, 07. 2 figs. 1600 w. 20c. Notes on an investigation by N. Wyncoop Kiersted on problems met with in securing water supplies from gravel strata.

High Pressure Fire Main System, New York.

New York's High Pressure System. Ins Engg—Aug., 07. 7 figs. 3700 w. 40c. Describes fire main system for protecting the congested value district, utilizing river water; the pumping stations to be operated by electric power.

Lime and Magnesia in Water, Estimation of.

The Estimation of Lime and Magnesia in Water by Volumetric Methods. W. T. Burgess. Chem Engr—Aug., 07. 1 fig. 2000 w. 40c.

Oriental Water Works.

Some Notes on Oriental Water Works. George A. Johnson. Eng Rec—Aug. 24, 07. 6100 w. 20c. Paper read before the American Water-Works Association.

Pipe Joints.

Joints in Underground Piping. Met Wkr—Aug. 17, 07. 1 fig. 2300 w. 20c. Describes methods of making lead and cement joints and their respective advantages.

Purification Plants.

New Water Purification Plant at Exeter, N. H. Robert S. Weston. Eng News—Aug. 8, 07. 12 figs. 3200 w. 20c. Describes coagulating basin and filter used.

The Water Purification and Softening Works at New Orleans, La. Eng Rec—Aug. 31, 07. 9 figs. 2800 w. 20c.

Water Supply System.

Metropolitan Water Works of Boston, Mass. Caleb Mills Saville. Mun Engg—Sept., 07. 3700 w. 40c. Discusses the distributing reservoirs and pipe lines of the system and also sanitary protection offered.

The Metropolitan Water Supply System. Caleb Mills Saville. Mun Engg—Aug., 07. 4 figs. 2500 w. 40c. Describes the various reservoirs, aqueducts and pumping stations.

MISCELLANEOUS.

Municipal Use of Patented Articles. Edgar H. Boles. Mun Jl & Engr—July 31, 07. 3100 w. 20c. Describes the present status of Supreme Court decisions and legislative enactments affecting patented articles for public improvements.

RAILROAD ENGINEERING

CONSTRUCTION.

Florida East Coast.

Progress on the Florida East Coast's Key West Extension. R R Gaz—Aug. 30, 07. 4 figs. 2100 w. 20c.

Mexico.

The Railroads of Mexico. Erdis G. Robinson. R R Gaz—Aug. 9, 07. 5 figs. 2500 w. 20c. The Principal Railroads.

Philippines.

The Railroad Development of the Philippines. P. H. Ashmead. Eng Mag—Sept. 07. 11 figs. 3000 w. 40c. Discusses progress made in construction and the industrial effects manifest.

S. P. and Santa Fe Cut-off.

A New Transcontinental Cut-off for the Southern Pacific and the Santa Fe. R R Gaz—Aug. 30, 07. 2500 w. 20c.

Tidewater and Deepwater Railways.

The Tidewater and Deepwater Railways. R R Gaz—Aug. 23, 07. 15 figs. 3400 w. 20c. III. Viaducts and Bridges.

Trans-Andine Railroads.

The Trans-Andine Railroads. Lewis R. Freeman. R R Gaz—Aug. [illegible], 07. [illegible] figs. 4400 w. 20c. Describes construction of the Chilean and Argentine Trans-Andine roads.

MANAGEMENT AND OPERATION.

Engineering Organization, W. P. Ry. Co.

The Engineering Organization of the Western Pacific Railway Company. George P. Low. [illegible]—Aug. [illegible], 07. [illegible] w. 20c. Describes the organization of the engineering forces, the reports, drawings and diagrams showing progress of work.

Freight, Improvements in Moving.

How One Railroad Moved Their Freight. Ivy L. Lee. System—Aug., 07. [illegible] figs. 5000 w. 40c. Describes the improvements in the routine system, the financial and operating methods, etc., that enabled the Penna. R. R. to take care of an increase of [illegible] in traffic in ten years.

Rates per Passenger per Mile, Charts for.

Railway Statistical Charts. C. Ward Schroeder. Ry & Eng Rev—Aug. 24, 07. 1 chart. 600 w. 20c. Gives chart showing the rate per passenger per mile.

Train Loads, Value of Increasing.

The Value of Railroad Improvements. Merrell W. Gaines. Eng Mag—Sept., 07. 4700 w. 40c. An examination of money earnings from increased train loads.

POWER AND EQUIPMENT.

Cars.

A New Pressed Steel Passenger Car. R R Gaz—Aug. 30, 07. 3 figs. 1500 w. 20c. Describes a design of steel passenger car built largely of pressed steel shapes.

Special Service Wagons: Great Central Railway Co. Engg—Aug. 9, 07. 2 figs. 1000 w. 40c. Describes types of English freight cars for handling goods of unusual bulk and awkward shape.

Depots, Cost of Frame.

The Cost of Four Frame Depots. Eng-Contr—Aug. 28, 07. 1700 w. 20c.

Freight Terminal.

Bronx Freight Terminal of the Central Railroad of New Jersey. Ry Eng & M of Way—Aug., 07. 4 figs. 2400 w. 20c.

Forest Planting.

Some Cost Figures on Forest Planting for Railroad Purposes. E. A. Sterling. Eng News—Aug. 29, 07. 1400 w.

Locomotives.

A Balanced Compound Locomotive for the Italian State Railroads. R R Gaz—Aug. [illegible], 07. Describes an express locomotive having among other features, an equalized connection of the driving and pilot axles in place of a four-wheeled truck.

A Note on Compound Locomotives. M. Maurice Demoulin. Engr—Aug. 23, 07. 3 figs. [illegible] w. 40c. A study for ascertaining why compounding has not produced better results when used on locomotives.

Bothwell Convertible Locomotive. Ry & Eng Rev—Aug. 3, 07. 4 figs. 900 w. 20c. Describes an ordinary 8-wheel locomotive equipped with supernumerary small geared drives which can be dropped to the track (the large drives being lifted from the rails) when on critical grades.

Causes of Leaks in Locomotive Boiler Tubes. Eng News—Aug. 29, 07. 5 figs. 2600 w. 20c. Gives the gist of a paper read by Mr. M. E. Wells before the Am. Ry. Master Mechanics' Assn., June 14.

Cleaning Locomotive Machinery. Ry Master Mech—Aug., 07. 5 figs. 1440 w. 20c.

DeGlehn Four-Cylinder Compound Locomotive, Paris-Orleans Ry. Ry Master Mech —Aug., 07. 4 figs. 1700 w. 20c.

Locomotive Smoke-Box Arrangements. E. W. Rogers. Boiler Maker—Sept., 07. 9 figs. 2500 w. 20c.

Locomotive Traction. J. Jahn. Z V D I —July 20, 07. 5 figs. 4000 w. 60c.

Locomotives for the Lancashire and Yorkshire Railway. Engg—Aug. 9, 07. 3 figs. 1200 w. 40c.

Mallet Compound Locomotives for Freight Service. Great Northern Railway. Ry Master Mech—Aug., 07. 5 figs. 600 w. 20c.

Pacific Locomotive for the Pennsylvania Lines. Ry Age—Aug. 23, 07. 4 figs. 1200 w. 20c.

Pacific Locomotive for the Pennsylvania Lines West. R R Gaz—Aug. 30, 07. 7 figs. 2800 w. 20c. Describes a 4-6-2 locomotive which is the heaviest passenger engine built up to the present time.

Sixteen-Wheel Mallet Compound Locomotive for the Erie. Ry Age—Aug. 9, 07. 5 figs. 1400 w. Aug. 16. 3 figs. 1000 w. Each 20c.

Six-Wheel Coupled Locomotive (Meter-Gage) for the Federated Malay States Railways. Engg—July 26, 07. 600 w. 40c.

Superheated Steam Passenger Locomotives (Series B ¾), Swiss State Railways. M. Weiss. Schw Bau—Aug. 3, 07. 6 figs. 2500 w. 40c.

Tests of the Live Load on Driving Springs. Charles A. Howard. Ry Age—Aug. 2, 07. 5 figs. 2300 w. 20c. Describes recording apparatus for testing locomotive springs.

The Use of Steel in Locomotive Construction. F. A. Lart. Cass Mag—Sept., 07. 2600 w. 40c.

Tractive Force of the Mallet Compound Locomotive. T. F. Crawford. Ry Master Mech—Aug., 07. 14,800 w. 20c.

Vanadium Steel for Locomotive Frames. C. C. Smith. Ry & Eng Rev—Aug. 24, 07. 1 fig. 1200 w. 20c.

Repair Shops.

Freight Car Repair Shop at McKees Rocks, P. & L. E. R. R. Ry Master Mech —Aug., 07. 15 figs. 2400 w. 20c.

Signaling.

Railway Signaling. W. E. Foster. El Jl—Aug., 07. 9 figs. 2800 w. 20c. VI.—Automatic block signaling, direct current.

Track.

Center-Bound Track as a Cause of Spreading Rails. Eng News—Aug. 15, 07. 1800 w. 20c. Abstract of a paper read in "The Technograph," Univ. of Ill., Champaign, Ill. Vol. XXI.

Construction of Second Track Accompanied by Reduction of Gradient. H. H. Knowlton. Eng News—Aug. 29, 07. 3600 w. 20c. Abstract of a paper in the "Purdue Engineering Review" for 1907.

Note on the Economic Renewal and Maintenance of Railway Tracks for High-Speed Traffic. Engr—Aug. 23, 07. 7 figs. 2200 w. 40c. Summary of a French civil engineer's investigation reported in the Bulletin of the International Ry. Congress, April, 07.

Notes on English Track. Eng News—Aug. 8, 07. 2200 w. 20c. Describes and illustrates joint and intermediate cast-iron chairs used on the Great Northern Railway.

Roadway Concrete Construction, C. B. & Q. Ry. Ry Eng & Main of Way—Aug., 07. 7 figs. 1400 w. 20c.

The Origin and Production of Corrugation of Tramway Rails. W. Worby Beaumont. Engg—Aug. 16, 07. 2000 w. 40c. Paper read before the British Association at Leicester, Aug. 6.

Track Elevation on the Milwaukee Division, Chicago & Northwestern Railway. Ry Age—Aug. 16, 07. 10 figs. 2500 w. 20c.

Train Resistance.

The Resistance of Railway Trains. Engg —July 26, 07. 1 fig. 3300 w. 40c. A summary and discussion of nine train-resistance formulas.

Turntable Pit.

Standard Turntable Pit: Seaboard Air Line Ry. Phillip Aylett. Eng News—Aug. 15, 07. 2 figs. 1500 w. 20c.

Warehouse.

Newark Warehouse of the Central Railroad of New Jersey. R R Gaz—Aug. 30, 07. 6 figs. 1300 w. 20c.

STREET AND ELECTRIC RAILWAYS.

Current Distribution.

Distribution of Current to Trains on Electric Railways. Ry Engr—Aug., 07. 4 figs. 2800 w. 40c. I. Distribution by continuous currents.

Electrically-Equipped Roads.

Construction Features of the Ocean Shore Railway. El Ry Rev—Aug. 3, 07. 10 figs. 3100 w. 20c. Describes the construction of a double-track, high-speed electric line, 83 miles long, now being built to connect San Francisco with Santa Cruz, Cal.

Electrification on the New York, New Haven & Hartford Railroad. E. H. McHenry. El Ry Rev—Aug. 17, 07. 5 figs. 4300 w. 20c. Descriptive of the work and equipment, by the vice-president of the road.

Great Western Railway. Tram Ry Wld —Aug. 1, 07. 2 figs. 1200 w. 40c. Describes the new electric supply system of the Great Western Railway, England.

Interurban Railway Development Near Milwaukee. St Ry Jl—Aug. 3, 07. 3700 w. 20c.

Interurban Traction Lines near Rome, Italy. A. de Courcy. West Elecn—Aug. 17, 07. 4 figs. 1800 w. 40c.

The Atlantic Shore Line Railway. El Ry Rev—Aug. 24, 07. 13 figs. 5000 w. 20c. Describes a recent opening by the Atlantic Shore Line Railway, a new railway connecting York Beach and Kennebunk, 16½ miles, making possible a through trip from New York City to Bath, Me.

The Electrification of the Hammersmith & City Railway Branch of the Great Western Railway (London). St Ry Jl—12 figs. 900 w. 20c.

The Pittsburg & Butler Street Railway Co.—II. M. N. Blakemore. Str Ry Jl—Aug. 17, 07. 20 figs. 4200 w. 20c.

Electric Traction.

Electric Locomotive of the New York, New Haven & Hartford Railroad. El Wld —Aug. 24, 07. 11 figs. 6000 w. 20c.

Electric Traction on Railways. Philip Dawson. Elecn—Aug. 9, 07. 3600 w. 40c. III. Remarks on the choice of accelerators and motors.

Single-Phase vs. Direct-Current Railway Operation. Malcolm McLaren. El Jl—Aug., 07. 4200 w. 20c.

Line Construction.

Catenary Line Construction on the New York, New Haven & Hartford Railroad. El Wld—Aug. 17, 07. 10 figs. 6400 w. 20c.

The Overhead Construction of the New Haven Railroad. Str Ry Jl—Aug. 17, 07. 20 figs. 5700 w. 20c. Deals in extensive detail with the overhead construction and transmission systems.

Power Stations, Interborough R. T. Co.

Principal Dimensions and Data of Power Stations, Sub-stations and Transmission System of the Interborough Rapid Transit Company. H. G. Stott. El Jl—Aug., 07. 4800 w. 20c.

Track-Laying Machine.

A Machine for Laying Rails in Streets. Sc Am Sup—Aug. 24, 07. 3 figs. 2500 w 20c. Describes apparatus for laying tracks without impeding traffic.

Train Testing Apparatus.

Improved Interurban Train Testing Apparatus. Sydney W. Ashe. St Ry Jl—8 figs. 5000 w. 20c.

NOTES FROM THE ADVERTISING MAN'S SCRAP-BOOK.

Industrial publicity is a new thing. It is still young and learning to walk. I sometimes think that no one appreciates the possibilities of publicity so much as the Publicity Man himself. And its appreciation in the industrial field is a thing of yesterday morning. The day before, no one thought of it. But "the old order changeth, yielding place to the new." For all that there is no industry that has all the publicity it needs; there is none that has begun to more than taste the fruits of advertising; there is no industry, there is no metal-working manufactory that spends money enough on publicity. Manufacturers are, no doubt, accustomed to say "Publicity costs so and so"; they are not yet accustomed to think "Publicity earns so much." That is a part of the lesson they have yet to learn. And they will learn it, and appreciate it. Yet I once knew a manufacturer who said: "We are getting too much publicity." There are evidences that his opinion is changing.—Arthur Warren, formerly Publicity Manager for Allis-Chalmers Company.

The American people want to know about everything; it's a part of their intelligence. An advertisement tells them about some one thing—tells them satisfactorily, if it's right. Then they want that thing.—"Printers' Ink."

The foremost advertising virtue is persistent repetition. One can no more make a single effort, however large, serve for a year's publicity, than he could get physical nourishment, for a like time, from a single dinner.—"Printers' Ink."

Are you advertising? You might as well think to win a foot race with your feet tied as to hope to increase your sales in these days without persistent, systematic advertising. Make up your mind now that you will increase your sales twenty-five per cent. this fall—more if you can, but no less. Lay your plans for a generous and well-planned advertising campaign that will make folks sit up and take notice. Get all the help you can and then determine to spend a liberal sum yourself. It will all come back to you with interest—in increased sales.—"Ralston Health Shoe Booklet."

TECHNICAL LITERATURE

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ELECTRIFICATION OF THE NEW YORK, NEW HAVEN & HARTFORD RAILROAD

By E. H. McHENRY, Vice-President

CONDENSED FROM THE "ELECTRIC RAILWAY REVIEW."

The terminal tracks of the New York & Harlem Railroad, between the Grand Central station, New York City, and the junction point at Woodlawn, 12 miles, are jointly leased and operated by both the New York Central and the New Haven companies. The zone of electric operation on the lines of the latter extends 21 miles farther, to Stamford.

The New Haven company was one of the earliest pioneers in the field of heavy electric traction, and has operated six of its shorter branch lines by electricity in commercial service for a number of years past, beginning as early as 1895.

The calculations and experience of the railroad company's engineers indicate that the total cost of a single-phase installation will be much less than that of the continuous-current system, and that the higher electrical efficiency, lower fixed charges, maintenance and operating expenses of the single-phase system all tend to reduct the relative cost of current delivery to the engine shoes in about the same proportion.

The choice of frequency was practically fixed by the manufacturing companies within limits of 15 and 25 cycles, and the comparative merits of these two rates only were considered. Under existing conditions it was decided that the practical commercial value of the higher frequency outweighed the more theoretical merits of the lower one.

Under general conditions it is altogether improbable that the direct savings resulting from the simple substitution of electric for steam power will be sufficient to justify the additional investment and financial risk.

It may be claimed for electric traction that it will extend the limits of profitable operation of high-speed heavy trains, and also of light trains of low capacity. Other but relatively minor advantages are possible in the effect upon earnings. The availability and value of real estate and structures at large terminals will be greatly augmented by the possibilities of using two or more superimposed track levels, as strikingly exemplified in the plans for new terminals in New York City for the new York Central and the Pennsylvania companies.

OVERHEAD SYSTEM.

Overhead Catenary Construction. — The overhead system consists of two steel cables of especially high strength, supported at intervals by steel bridge structures. A copper conductor or trolley wire (No. 0000 B. & S. gauge grooved) is suspended below the two supporting cables by means of hangers placed at frequent intervals.

The main conductors over the running tracks are paralleled throughout their entire length from Stamford to Woodlawn by two feeder wires. These feeders constitute aux-

iliaries to the main track conductors and are connected with the latter at each anchor bridge through circuit-breakers. The office of the auxiliary feeders is to provide means for feeding around any one section in case it is cut out of service on account of some accident in that particular section.

All bridges are placed at a fixed distance of 300 feet apart. On curves guide poles are provided from which pull-over wires are attached and secured to the catenary spans.

The general appearance of the standard 4-track intermediate bridge is shown in the illustration. It consists of two supporting side posts and a horizontal truss. Each supporting post is approximately 38 feet long by 1 foot 10 inches square. The cross truss is attached by means of bolts to the vertical posts, allowing a distance of 23 feet 4 inches from the lower side of the truss to the top of the rails. The truss is 4 feet 6 inches deep from back to back of the upper and lower chord angles, which latter are placed 1 foot 10 inches from back to back.

The extensions of the side posts above the trusses are utilized for supporting the feeder wires.

In the calculation of these bridges very heavy weather conditions were assumed and provision was made for clamping the catenary cables on the intermediate bridges so that they are obliged to partially withstand the longitudinal pull of the latter.

Anchor Bridges.—Anchor bridges of especially heavy construction are placed every two miles, and against these bridges the catenary cables are anchored. An illustration represents a transverse view of a standard 4-track anchor bridge with the auxiliary apparatus mounted upon it. Signals are also mounted upon the bridge. The 4-track anchor bridge consists of two A-shaped posts having a spread at the base of 15 feet and a width at right angles to the track of about 2 feet.

Catenary Cables.—Each of the two catenary cables which support the copper trolley conductor comprises an extra high strength steel cable, 9-16 inch in diameter, consisting of heavy strands. The cable has an ultimate strength of 22,800 pounds. These cables are strung between the bridges, with a sag at mean temperature of 6 feet in a standard span of 300 feet.

Main-Line Insulators.—The insulating supports for the catenary cables on the intermediate bridges consist of heavy porcelain insulators of the skirt type, which are 13 inches in diameter and about 7 inches high. The catenary cable rests in a groove in the top of the porcelain and is held by means of a malleable iron clamp fitted with U-bolts and placed one on each side of the insulator. The head of the insulator is conical in shape and is surrounded by means of a split malleable iron clamp and a lead packing.

LATEST TYPE OF SINGLE-PHASE ELECTRIC LOCOMOTIVE, NEW YORK, NEW HAVEN & HARTFORD R. R.

ANCHOR BRIDGE, OVERHEAD CONSTRUCTION, NEW YORK, NEW HAVEN & HARTFORD R. R.

The construction of the clamp and the collar is such that in case of the breakage of the messenger cable on one side of the insulator, the pull of the cable on the other side will cause the clamp to swing downwards, thereby lowering the point of application of the pull of the cable, so that the porcelain is put in compression and there is no tendency to shear off the top of the porcelain, as is usually the case with porcelain line insulators. Each porcelain stands a shop test of 55,000 volts assembled.

Strain Insulators.—The insulators which are used for dead-ending the catenary cables at the anchor bridges are designed to stand a shop test of 55,000 volts and a working load of 20,000 pounds. One of these insulators is provided in each catenary cable at each anchor bridge, thereby dividing the road into separate sections between the anchor bridges.

The guy-pole strain insulator is somewhat similar in appearance to the well-known "giant strain," except that it is much larger and is designed to stand a test of 50,000 volts and a mechanical pull of 15,000 pounds.

Insulating Separators.—In order to enable any one track to be electrically disconnected from any other parallel track when the circuit-breakers on the anchor brides are open, insulating separators are provided in the pull-over wires between the tracks. They consists of long rods of selected hickory, thoroughly impregnated and fitted at the ends with malleable iron heads secured to the conically shaped heads of the rods by means of bolts. These insulators have an ultimate tensile strength of about 16,000 pounds.

At no point in the entire construction is wood relied upon for insulation to ground, and it will be noted that these wooden separators normally have no difference of potential upon them. They are merely provided in case of accident, when it is necessary to isolate one section of track from another.

Trolley Hangers.—The trolley wire is supported every 10 feet from the catenary cables

by means of triangular trolley hangers of varying lengths. These hangers are so adjusted in length that the trolley wire is maintained in a horizontal position, it being 6 inches below the catenary cables at the middle point of the span.

Trolley Section-Break Insulators.—At each anchor bridge it is necessary to provide an insulator and a trolley wire. This is accomplished by means of two bronze end castings, to which the ends of the trolley wire are bolted. Two parallel sections of impregnated hardwood are fastened to these castings, and to these wooden strips are fastened renewable pieces of trolley wire in such a manner that the ends of these renewable pieces overlap one another. By this means it is possible for the sliding contact on the locomotive to pass from one section to the next without opening the circuit, thus avoiding all flashing.

A diverging trolley wire is connected to the main wire by means of a frog of standard design, and in order to prevent the contact shoes on the locomotive from catching, deflector wires are placed in the angles between the two trolley wires.

Automatic Circuit-Breakers.—The type of circuit-breaker which has been developed for this installation consists of a cast-iron framework adapted to be bolted to channel irons resting upon the upper chords of the anchor bridges. This framework carries an iron box provided with a hinged cover. Arrangements are provided so that if the cover is opened the circuit-breaker will be automatically tripped so as to prevent any possibility of the attendant taking hold of live parts.

The circuit-breaker is of the well-known Westinghouse design and is capable of handling 11,000 volts on heavy short-circuit. The switch is also arranged to open automatically on overload.

The control wires for the closing magnets and the tripping coils are carried in iron conduit and lead-covered cable to the adjoining signal tower, where a switchboard panel is provided.

Track.—Both rails of all tracks are bonded by means of No. 0000 compressed terminal flexible bonds placed around the fish plates.

POWER HOUSE.

Power House Building.—The power house is located adjacent to the main line of the railroad and on the bank of the Mianus river, about one mile from Long Island sound. Coal can be delivered either by water or rail, and an unlimited amount of salt water is available for condensing purposes.

Turbo-Generators.—The initial generating equipment of the power house consists of three multiple-expansion parallel flow Parsons steam turbines direct connected to single-phase Westinghouse generators. Provision has been made for the installation of a fourth unit of corresponding size. The turbines are rated at 4,500 brake horsepower each and the generators at 3,000 kilowatts each, at 80% power factor. The generators are wound for three-phase current, but arranged for the delivery of both three-phase and single-phase current.

The excitation of the generator fields is provided for by two 125-kilowatt direct-current generators, direct connected to Westinghouse engines; and one motor-driven exciter.

A separate condensing outfit is provided for each turbine, consisting of an Alberger three-phase counter-current surface condenser, a two-stage dry air pump, a centrifugal circulating pump direct connected to a Westinghouse engine, and a Monitor hot-well pump, the speed of which is automatically controlled by a float.

To prevent the rapid deterioration of the brass condenser tubes by the galvanic action which usually occurs where salt water is employed for condensing purposes, a motor generator set has been installed and provided with suitable controlling apparatus for maintaining in each condenser a counter electromotive force slightly in excess of the electromotive force due to the galvanic action and the stray currents.

Boilers.—The initial installation consists of twelve 525-horsepower Babcock & Wilcox water-tube boilers, set in batteries of two boilers each. Provision is made for four additional boilers to take care of the fourth turbo-generator unit when it is installed. These boilers are equipped with Roney mechanical stokers and Babcock & Wilcox superheaters and deliver steam at 200 pounds gauge pressure and 125 degrees superheat.

A novel feature of the boiler settings is the installation of an external steel casing entirely inclosing the brick work, thus rendering the setting impervious to air leaks.

Three Green fuel economizers are provided, each inclosed by means of metal sectional covering insulated with prepared asbestos blocks.

Coal-Handling Installation.—All coal received by water is unloaded from the barges by a steel derrick operating a clam shell bucket

and delivered mechanically into two flight conveyors, extending the length of the boiler room, which discharge the coal into spouts leading to the stoker hoppers of the boilers.

Coal received by rail is dumped from the car directly into a chute leading to a storage bin.

The ashes are disposed of by gravity into chutes leading to narrow-gauge cars in the basement.

ELECTRIC LOCOMOTIVES.

The average train load on the New Haven road is 210 tons, and the locomotives have been built according to specifications requiring that each locomotive shall be able to haul a 200-ton train at a speed of 65 to 70 miles per hour, and a 250-ton train at 60 miles per hour. Heavier trains—up to 600 tons—will be hauled by two or three locomotives in multiple and operated as a single unit.

The locomotive body is carried on two four-wheel trucks, each wheel of which is a driver.

The current is collected from the overhead conductor by means of two pantagraph bow frames, the upward pressure against the wires being supplied by springs in the base of the pantagraph frame, which is made of steel tubing. The collector bow is a broad strip of soft copper. For use on the New York Central tracks the locomotives are provided with a pantagraph trolley for use on direct-current overhead conductors, and also third rail contact shoes, for use on either overrunning or underrunning rails.

Some of the general dimensions and details of these locomotives are as follows:

Total length over buffer platform	26 ft. 4 ins.
Extreme width	9 ft. 7½ ins.
Height to top of cab	12 ft. 2 ins.
Driving wheels, diameter of	62 ins.
Trucks, c to c	14 ft. 6 ins.
Wheel-base, one truck	8 ft.
Wheel-base, total	22 ft. 6 ins.
Total weight on drivers	93 tons
Motors	4 Westinghouse, each 250 HP.
HP. of locomotives	1,000
Draw-bar pull	5,000 lbs. at 65 mi. per hr. (maximum 20,000 lbs.)

THE TREND OF STORAGE BATTERY DEVELOPMENT

By L. H. FLANDERS

FROM "THE ELECTRIC JOURNAL."

In considering the development of storage batteries, two questions naturally arise: Why are lead plates with sulphuric acid the prevailing types of battery? Why does not development manifest itself along new lines using metals of higher capacity per unit of weight than lead? Experience and the present status of electro-chemistry indicate that there is very little probability of securing successful storage batteries unless the following conditions be met:

First—That the metals and their salts which compose the plates be insoluble in the electrolyte.

Second—That when the plates are completely charged no decomposition of the electrolyte takes place with the exception of the breaking up of the water into hydrogen and oxygen.

It is true that other metals have been tried which dissolve on discharge and are redeposited on charge, but such plates have never been successful on account of the difficulty of controlling the metallic deposit. These two principles immediately narrow the choice of electrolyte to caustic potash or soda, and sulphuric acid. The first two have the disadvantage that they carbonate on exposure to the air. Furthermore, the alkaline electrolyte is only usable with cells of the so-called "oxygen lift" type such as the Edison battery. This type of cell has not reached commercial importance and, on account of the high cost of materials, the relatively low efficiency and the mechanical difficulties encountered in its manufacture, will probably have a very limited application, principally to electric vehicle propulsion.

In regard to the plates, lead is the only available metal which is insoluble in sulphuric acid, and this, coupled with the fact that lead peroxide and lead sulphate are also insoluble, accounts for the general use of the lead-sulphuric acid type of storage battery. Another cause leading to the further use of lead is that next to iron it is the cheapest available metal [illegible].

The development of the lead-sulphuric acid type of storage battery has been along two [illegible]:

First, batteries intended mainly for stationary service.

Second, batteries for vehicle propulsion.

[illegible]

For [illegible] the beginning of the discharge of a charged cell the elements consist of positive and negative plates in a solution of sulphuric acid. The positive active material is peroxide of lead which surrounds a supporting conductor. The negative element consists of spongy lead supported by a conductor. The sulphuric acid permeates the pores of the active material of the plates. During discharge the active material of the plates contains an increasing amount of lead sulphate and the electrolyte contains a decreasing percentage of sulphuric acid. At the end of the discharge the active material of both plates has been reduced to sulphate of lead and the electrolyte has been changed to water. [illegible] the positive plate has [illegible] the hydrogen of the sulphuric acid [illegible] water, the sulphate having combined with the lead of the active material. [illegible] sulphate and the [illegible]. Upon charging, the [illegible] plate. The water in the [illegible] sulphuric acid formed [illegible] the plates and [illegible] the water. The oxygen of the water [illegible] the lead of the positive [illegible] the battery is in the [illegible] discharge and recharge [illegible] beginning of the discharge. [illegible] might be inferred that [illegible] has no depreciation, but [illegible] the case.

[illegible] lead plates are of [illegible] the Planté and the Faure. The [illegible] is not used as a positive [illegible] service in this country. [illegible] capacity per unit weight, [illegible] is in relatively [illegible] and disintegrates more [illegible] of the Planté [illegible] from the grid itself, [illegible] a conductor [illegible] the pasted [illegible] sulphate [illegible] the current [illegible] difficulty is ex[illegible] condition [illegible] are liable [illegible] disadvantage [illegible] negative plates [illegible] the peroxide [illegible] which [illegible] to the [illegible] in which the [illegible] surrounded by [illegible] lead. This hard [illegible] the growth

of the pure lead pellets is restrained. In some plates, the active portions, in the form of biscuits two to three inches square, are attached to one side of the lead antimony frame, with open spaces between the biscuits and the other three sides of the frame to allow for their growth. In one type of plate the biscuits are attached at the two opposite sides of the antimony frame and are left free to expand at their ends. A grooved lead plate with a Plantè formation will grow in length, that is, in the direction of the grooves rather than transversely. Aside from the disadvantage of buckling or warping, which is liable to produce short-circuits between the adjacent plates, the integral pure lead plate possesses decided advantages over the composite type of Plantè plate. The futility of attempting to prevent the growth of the active portions of the plate has been recognized and, therefore, provision has been made for this growth so that it will take place within the confines of the plate itself. The buckling effect is thus confined to the individual section and does not develop in the plate as a whole. Such a plate is of one piece of pure lead without joint or weld and, as a consequence, has a very low internal resistance. It is so constructed that all over the plate, the current and the electrolyte are equally accessible to the active material. It should be stated that the plate is divided into thirty-six active portions consisting of longitudinal laminations, surrounding the surface of which is a thin layer of peroxide of lead. Between these biscuits and connecting them, is a corrugated sheet. As the plate grows, the sections extend in length, thus closing up the corrugated expansion joints, but taking up the growth within the plate itself.

Negative Plates. The pasted type of negative plate is largely used, but possesses the disadvantage of requiring careful handling. On the other hand, the ordinary form of Plantè negative is exceedingly durable and will stand all sorts of abuse without mechanical disintegration. It will not, however, maintain its capacity, which drops in a few hundred discharges to from 50 to 25% of its initial value. The capacity may be temporarily restored by charging the negative to positive and back again to negative, or completely reversing it. This loss of capacity tends to prevent the adoption of this form of Plantè negative plate. This loss may be explained by the shrinkage of the negative material caused by the cohesion of the pure lead walls of the spongy lead mass constituting the active material. This will be appreciated when it is explained that the negative active material, when fully charged, is lead of the utmost purity and that any oxidization is prevented by the bath of nascent hydrogen given off when the plate is charged, and that clean surfaces of lead may be united by simple pressure. Due to the contraction and expansion of charging and discharging, the thin walls of some of the pores throughout the active mass collapse and stick together, thus reducing the porosity and consequently the capacity of the plate.

In a Plantè negative plate lately developed inert material has been introduced into the pores of the spongy mass, which has evidently prevented the collapsing and sticking together of the walls of the porous material, since the plates have a sustained capacity for an apparently indefinite time. Since there is no corrosion and disintegration in the Plantè negative plates, the lead conductors and supports are made lighter than in the positive plates and no provision is made for expansion.

ELECTROLYTE.

There is little probability of any development being made in the electrolyte beyond increasing and maintaining its purity.

CONTAINERS.

The most durable form of containers for stationary batteries are glass jars and tanks, but these are limited in size and are also liable to breakage during installation when of large size. Lead lined wooden tanks are used for elements that are too large for mounting in glass jars. These are very satisfactory, provided the wooden parts of the tank are kept clean and frequently painted. Efforts are being made to manufacture glazed earthenware tanks. If successful, these will prove absolutely permanent and, while their first cost will probably be somewhat higher than lead lined wooden tanks, the reduced maintenance charge will more than compensate for this increase.

MATERIALS FOR INSTALLATION.

Too much care cannot be taken in seeing that the batteries are properly installed as proper installation is a large factor in reducing the maintenance expense. The plates should be adequately separated from each other. A new form of plate support is grooved glass, the edges of the battery plates being held in vertical grooves in these glass plates. In this way the plates are kept uniformly spaced and short-circuits around the plates are prevented.

Great care should be taken to secure proper insulation of the battery cells from each other and from the ground. The heating and ventilating of the battery room is also of great importance. The available normal capacity of the battery, at the eight-hour rate of discharge, is reduced 0.56% for each degree Fahrenheit drop in the temperature below the normal 70°.

When the surface of the tanks becomes coated with a film of sulphuric acid, this surface never dries, and the film must be removed by neutralizing with caustic soda. This action is explained by the fact that sulphuric acid, beyond a certain density, is hygroscopic and therefore will absorb water from the air. By using the exhaust system of ventilation, the sulphuric acid spray given off by gassing, may be withdrawn so that it will not precipitate, while if a blower is used, eddies of air will deposit the spray in a thin film over everything in the room.

AUXILIARY ELECTRICAL APPARATUS.

In order to secure the maximum value from a storage battery installation, the electrical auxiliary apparatus in the way of boosters, switchboards, etc., must be of ample capacity. Attempts to overwork the auxiliary equipment on over-load is "penny wise and pound foolish," as this part of the equipment, while it approximates only from 10 to 25% of the total cost of the installation, is absolutely essential to its successful operation.

CARE AND OPERATION.

A storage battery requires periodic, but not excessive care to secure the best results. Unlike engines, generators and motors, the storage battery, when abused, gives no audible and seldom any visible signs that it is not working properly, but continues to deliver current until it may be severely injured.

By using the specific gravity method of charging, that is, charging until the specific gravity of the electrolyte returns to the original value that it had at the beginning of the discharge, the efficiency and life of a battery may be much greater than when methods depending upon the voltage only are used. The specific gravity method is based on the fact that for each ampere-hour discharge, a definite amount of sulphuric acid is transferred from the electrolyte to the plates in the form of sulphate. Conversely, this sulphate is returned to the solution on charging. The change of specific gravity of the electrolyte is independent of the rate of discharge, so that knowing the change in specific gravity of the electrolyte for a normal discharge of the battery, the energy taken out at a varying rate of discharge can be determined at any time.

The persistent use of the auxiliary cadmium electrode to determine whether trouble is caused by the positive or negative plates should be encouraged. The use of distilled water for replenishing the loss in the solution due to evaporation and care in preventing impurities from getting into the cells should be insisted upon.

The storage battery, as now installed, is one of the most reliable pieces of apparatus available for the electrical engineer. The life of the negative plates is now indeterminate. The positive plates last from four to eight years, depending upon the service. Storage battery manufacturers make it a practice to enter into maintenance contracts with their customers, guaranteeing that the maintenance cost will not exceed 7 to 10% of the cost of the battery for a period of 10 years. Unlike other machinery, at the end of 10 years, the installation will have the advantage of the latest developments in the art since, in renewing the plates, the latest types can be used. It is worthy of note that several millions of dollars have been invested in storage batteries by the prominent illuminating companies, these batteries being used simply for insurance against shut-down. They are only discharged when there is something wrong with the regular supply. At all other times they are kept fully charged and floating on the system. This shows the reliability and value of the storage battery of the present day in large power plants.

THE FORGING OF ALLOY STEELS

By E. F. LAKE

CONDENSED FROM THE "AMERICAN MACHINIST."

e alloyed steels, such as nickel, chro- ı, vanadium, silicon, tungsten, and sev- ›ther alloys as well as different combina- of these, are coming into more general ›very day for the parts of high-grade inery which are subjected to a high rate ar, which have to support a great weight hich are subject to excessive strains, es and vibration.

ny of the parts for which these alloyed are used are too intricate in form to he regular rolling-mill shapes, and the d steels have not, as yet, been cast suc- illy, except in a few instances.

these parts which cannot be produced the rolling-mill shapes, or made in cast- forging is resorted to, and there are sev- lifferent ways of turning out these forg- by hand, under a steam hammer, in a ulic press, or in a drop-forging press.

en small pieces and but few of a kind anted, the hand forging is undoubtedly heapest; but for large pieces, or where ge quantity is wanted, hand forging is ost expensive way of producing them he strength is not apt to be as great as y of the other methods. With a black- shop, properly equipped, a skilled smith ake forgings that are stronger than a bar from the same ingot. To do this st be hammered between the proper tem- ıres, which vary with different alloys of

ickel-chrome steel must be kept at 2200° hich is a bright yellow color, all through rging operations, while some of the car- teels, particularly those that are high in n, cannot be heated to a temperature 1800 F., without burning the metal; and once burned it cannot be returned to ormer state without remelting. The r the carbon content the more danger is of burning, and a steel 1% of carbon ry difficult to forge at all owing to the mely low temperature at which it must orked. The smith must also regulate the weight and effect of the blows so that it will be finished just as it reaches a blue heat. This will prevent the formation of large crystals, give the piece a dense, homogeneous grain with the atoms holding together by a high cohesive force and result in the steel having an increased strength.

In many of the more intricate shapes that are hand forged, a resource is had to welding, and if the average smith were told that he could not make a perfect weld, he would feel greatly insulted. But from a large number of so-called perfect welds that were examined very few showed a strength equal to 50% of the unwelded section. With the alloy steels it is difficult to get a weld that will even show that percentage, as nickel, chromium, vanadium, tungsten, aluminum and some other alloys do not lend themselves to the welding process.

Carbon, however, is the principal enemy of welds and with this as low as 0.15% it must be handled with great care at the welding heat, while with 0.20% of carbon the steel is very unreliable and with 0.50% of carbon the steel is liable to be burnt at a temperature well below the welding heat.

Thus to make hand forgings where welds are necessary the pieces must be from 2 to 3 times the size of that necessary for the required strength and with some of the alloyed steel even this will not suffice.

Where electric or acetylene blowpipe welding is resorted to these bad features are overcome to a great extent and stronger welds are secured, as these methods melt the metal, allowing it to run together and then solidify, thus making a more perfect joint.

The steel which is the best adapted for forging under the hammer has about the following composition: Carbon, 0.15%; silicon, 0.20%; manganese, 0.52%; phosphorus, 0.06%; sulphur, 0.04%.

This steel in the annealed state will show the following physical characteristics: Tensile strength, 55,000 lbs. per sq. in.; elastic

limit, 30,000 lbs. per sq. in.; elongation in 8 ins., 29%; reduction of area, 60%.

When fractured it will show a silky fiber.

But for many purposes a steel of much greater strength than this must be hand-forged and then it becomes necessary for the smith to understand the nature of its component parts so he can forge it successfully, as many of the high-grade alloy steels can be rendered no better or stronger than the ordinary carbon steels by over or under heating and poor workmanship.

In many cases welds are absolutely necessary to produce the required shapes and a steel of the following composition is the best suitable for welding: Carbon, 0.080%; silicon, 0.035%; manganese, 0.110%; phosphorus, 0.012%; sulphur, 0.007%.

In the annealed state it should show the following physical characteristics: Tensile strength, 48,000 lbs. per sq. in.; elastic limit, 25,000 lbs. per sq. in.; elongation in 2 ins, 27%; reduction of area, 69%.

For such work, however, a nickel steel casting that is much cheaper than forging, is being produced by one foundry that shows the following physical characteristics: Tensile strength, 78,000 lbs. per sq. in.; elastic limit, 50,000 lbs. per sq. in.; elongation in 2 ins., 25%; reduction of area, 42%.

Direct steel castings are being turned out by several foundries that show the following physical characteristics: Tensile strength, 70,000 lbs. per sq. in.; elastic limit, 35,000 lbs. per sq. in.; elongation in 2 ins., 25%; reduction of area, 40%.

These steel castings can be forged, welded, bent cold, tempered, and in fact worked about the same as rolled steel. The nickel-steel castings can also be case-hardened, and are successfully used in place of forgings.

For pieces of considerable size and bulk the steam hammer is substituted for the hand-forging process. In this method of forging the hammer should be of a size to suit the size of the work. The hammerman must exercise a good deal of skill and judgment as to the power and speed of the blows delivered to the piece, as a too powerful blow will crush it and in the case of a high percentage of nickel, fissures and cracks are liable to develop which it will be difficult to get out, and which may show in the finished product.

This is especially true if the piece is allowed to fall below the forging temperature, or if the blows are not distributed evenly. If the blows are from a light triphammer, delivered at high speed, only the surface of the metal will be bruised and the core not affected, thus causing the core to be coarse-grained without the proper adhesion to insure the necessary strength.

A heavy hammer descending on the work at a slow speed will penetrate the mass to the center and allow the particles of metal to flow to their proper position and insure a fine grain of even texture and be uniform throughout its entire size.

THE LIQUEFACTION OF GASES

By ROGER BALDWIN COLTON

[illegible]

The first recorded [illegible] the liquefaction of air was made by Perkins, [illegible] man, in 1823. He claimed to have [illegible] under a pressure of [illegible] 200 lbs. per sq. in. [illegible] a small quantity of liquid [illegible] and odorless, [illegible] It is now [illegible] merely condensed [illegible] the air itself [illegible] The first successful [illegible] the liquefaction of any real gas was that of Northmore in 1805-6. Northmore, while experimenting to [illegible] the effects of pressure on gas, compressed [illegible] chlorine gas and obtained [illegible] inches of a yellow [illegible] His work was, how-[illegible] and was little known. [illegible] that Faraday at first [illegible] liquefied chlorine in 1823, [illegible] Faraday in fol-[illegible] on liquefaction [illegible] could not be liquefied by [illegible] pressure if their temperature was above a certain point. Certain gases which cannot be liquefied at atmospheric tem-

perature, were liquefied by Faraday by placing the free end of his bent tube in a freezing mixture and continuing the same process as before.

Faraday was unable to liquefy oxygen, nitrogen, carbon monoxide, or hydrogen. He suggested that if these were reduced below a certain temperature peculiar to each that they could be liquefied. Scientists, however, did not realize the importance of temperature in liquefaction, and it was not until Andrews, of Belfast, performed in 1869 a series of experiments, mainly on carbon dioxide, which completely substantiated Faraday's views, that men began to attempt liquefaction by means of low temperatures. Andrews in his magnificent series of experiments was able to show that carbon dioxide when raised to a sufficiently high temperature could not be liquefied by pressure, obeyed the gas laws very closely, and behaved in every respect like one of the so-called permanent gases (oxygen, hydrogen, etc.). However, when carbon dioxide was lowered to a temperature of 31° Centigrade (304° Abs., 88° F.) it could be liquefied by 72 atmos. pressure, while, as we have already noted, above this temperature it could not be liquefied. This temperature (31° C.) and pressure (72 atmos.) he called the critical temperature and pressure of carbon dioxide. The almost inevitable conclusion was that air and the other permanent gases were simply far above their critical temperatures and could be liquefied when, and only when, they were reduced to it.

Below are some critical constants which have since been found experimentally, or calculated:

	Critical Temperature			Critical Pressure.
Carbon Dioxide	31° C.,	88° F.,	304° Abs.	72.4 Atmos.
Hydrogen	—238° C.,	—396° F.,	35° Abs.	15.3 "
Nitrogen	—149° C.,	—236° F.,	124° Abs.	27.6 "
Oxygen	—119° C.,	—182° F.,	154° Abs.	58. "
Air	—140° C.,	—220° F.,	133° Abs.	39. "

Since Andrews' time, therefore, the problem has been to lower the temperature, or as the popular expression has it, produce cold. There are three well recognized methods of doing this: namely, (1) by the rapid solution of a solid, (2) by the rapid evaporation of a volatile liquid, (3) by the rapid expansion of cooled and compressed gas. Up to 1820 the first method—which is the familiar method of mixture, such as salt and ice water mixture which is used to freeze ice cream—was used almost entirely, and by this method a temperature of —50° C. had been attained. The second method is common, but not commonly recognized; an example is the sensation of cold produced whenever one's skin is wet with water. The cold is due to the rapid evaporation of the water. As for the third method, it is a matter of common knowledge that when a gas is compressed it becomes hot, therefore when it is expanded it becomes cold. This holds true for any method of expansion for any gas, excepting when hydrogen is expanded without doing work.

Pictet, of Geneva, Switzerland, and Cailletet of France each succeeded in liquefying air and oxygen in 1877. Pictet's work was the result of a direct and scientific application of the principles of Faraday and Andrews. Pictet endeavored to lower the temperature and at the same time apply an enormous pressure. He employed a cast iron retort in which was placed a certain amount of potassium chlorate, which, when heated, gives off oxygen gas. By simply heating the retort the tube leading from the top could be filled with oxygen at any desired pressure. But pressure is only one, and not the important condition in liquefaction. In order to cool the compressed oxygen in the tube, it was surrounded by a condenser jacket, containing liquid carbon dioxide. To increase the cold a compressor constantly exhausted the carbon dioxide vapor from the condenser jacket. This caused the liquid carbon dioxide to evaporate, rapidly reducing the temperature to —140° C. (—220° F.). The carbon dioxide exhausted from the condenser jacket was then compressed by the compressor and was forced out into a pipe surrounded by liquid sulphurous acid evaporating under reduced pressure and giving a temperature of —25° C. (—13° F.). The carbon dioxide, however, was constantly expanding as it passed through the pipe, and having fallen in pressure to 5 atmospheres and in temperature to —65° C. (—85° F.) it was liquefied and forced back into the condenser. The sulphurous acid went through a like cycle, the heat of compression being removed by cooling water, it expanded, was liquefied, and passed back into the condenser jacket to be exhausted, condensed, and liquefied again. The oxygen, then, having had its heat of compression removed and being further reduced in temperature to —140° C. (—220° F.), was allowed to expand through a nozzle. Its temperature then fell so far below its critical temperature that part of it liquefied at atmospheric pressure and it fell in a stream on the floor.

Cailletet's method was to compress oxygen or air in a small glass tube to the pressure of 200

atmospheres by means of a hydraulic press, keeping its temperature at −25° C. (−13° F.) by means of sulphurous acid evaporating under reduced pressure. He then released the pressure from the pump end of the apparatus and the oxygen became so cold on expanding to its original volume that it appeared as a mist.

For many years no one seemed to see the importance of Cailletet's method of producing the necessary cold by expansion of the gas to be liquefied itself. However, Dewar of England soon succeeded by further application of both Pictet's and Cailletet's methods to produce considerable amounts of liquid air. In time though he dropped off the features of Cailletet's method and by further extension and improvement of Pictet's cooling cycles was able to produce large quantities of liquid air, oxygen, nitrogen, etc., but at the enormous expense of some $500 per pint of liquid. Dewar also succeeded in obtaining a small amount of liquid hydrogen.

The next great step in the liquefaction of gases is the method of self intensification or regeneration of cold. This method is due to several men: Tripler of New York, Linde and also Dewar to a case, [illegible] the method at about the same time. It is simple to operate and easy to understand. The gas is forced by a compressor at from [illegible] atmospheres [illegible] [illegible]

at atmospheric pressure. A portion of the issuing gas is then constantly liquefied and is collected in a vessel placed beneath the nozzle for that purpose.

In the above system no cooling beyond that of the atmosphere is needed—except in the case of hydrogen—however, the efficiency of the system is very much increased by precooling. The process being therefore almost entirely mechanical would naturally be cheaper than one involving the expensive cooling cycles of Pictet and Dewar. This is illustrated by the fact that Tripler, using his self-intensive or regenerative process, claimed to be able to sell liquid air at 20 cents per gallon, whereas Dewar estimated the cost of liquid air at $500 per pint.

The conditions of expansion from the pinhole valve of the modern regenerative coil very closely approximate that of expansion without external work, such, for instance, as allowing gas to expand into a vacuum vessel. This method was first studied by Joule and Thomson in 1845. They found that most gases cooled on free expansion, hydrogen alone becoming heated. Further more the cooling effect was different for different temperatures, being expressed for air by the formula, [illegible] and for hydrogen by, $x = \frac{64.1}{T}$ [illegible]

[illegible] where x is the cooling in centigrade degrees per atmosphere drop in pressure, and T is the absolute temperature. These equations seem to show that for air the cooling effect [illegible] there is a heating effect) [illegible] F.), while for hydrogen there is a heating effect above 194° [illegible] F. and a cooling effect below this temperature, and such has been [illegible] the case. Therefore by cooling [illegible] the temperature of liquid [illegible] through a regenerative [illegible] has been obtained in [illegible] one of the last [illegible] the permanent [illegible]

RECENT ADVANCES IN ARTIFICIAL ILLUMINATION

FLAMING ARC, METALLIC ARC, MERCURY VAPOR AND VACUUM TUBE LIGHTS

CONDENSED FROM "ENGINEERING NEWS"

Light From Gases and Vapors.—Whenever a gas or a vapor is made luminescent, certain definite wave lengths of light are always given off and a definite spectrum is always obtained for each gas or vapor. When the atoms or molecules of a gas or vapor are caused, by electrical means, to move in such a manner that light is produced, heat also is produced as a result of the electrical conduction; but the temperature is not related to the quality of the light except in the case of metallic vapors, when a certain temperature may be necessary for the existence of the vapor in quantity. This phenomena is the reverse of that generally observed in the case of incandescent solids, where the light is directly related, both in color and amount, to the temperature. Gases and vapors may be made luminant by electrical stress in vacuum tubes and by electric arcs.

Direct and Alternating Current Arcs.—The spectrum of an arc is that of the vapor of the negative electrode, and is independent of the material of the positive electrode, except as materials held therein enter the arc vapor as a result of the high temperature attained. An arc is essentially a direct-current phenomena, and except under definite conditions cannot exist with an alternating E. M. F. Even when so existing, the alternating-current arc is formed by a succession of separate direct-current arc streams. At the end of each half wave length, the current dies away, and with it dies the vapor stream. The next half wave of E. M. F. having a reversed direction necessitates that the current, and therefore the vapor stream, should pass in the reverse direction from that of the first half wave length. The continuity of the arc to the eye is broken if the supply voltage is not high enough to cause a current to pass through the residual vapor between the electrodes. The voltage required to jump a spark across the gap between terminals decreases with an increasing temperature, while the voltage across an arc increases with the arc temperature and therefore with the boiling point of the electrode material. Now with electrodes of certain materials the voltage across an arc becomes equal and even higher than would be required to jump a spark between the electrodes at the temperature of the residual vapor. Such electrodes allow the apparently steady maintenance of an arc between them with alternating current. The arc streams, however, are separated and continually reversing with a frequency corresponding to that of the supply current. The stroboscopic effects of alternating current arcs are the result of this reversal of vapor streams. Carbon is such a material as above described, and the development of an alternating-current lamp from the old direct-current types was possible without much experimenting and before the theoretical considerations for the maintenance of alternating-ing current arcs were thoroughly understood or widely appreciated.

The old direct-current lamp was first improved by enclosing the electrodes in a more or less air-tight globe. This reduced the consumption of carbon electrodes and the cost of attendance, but at the expense of efficiency of actual illumination. The esthetic effect was materially improved by the diffusing action of the enclosing globe. Where once it was possible to see only the old open arc itself, on account of its great intrinsic brilliancy, with the enclosed arc it became possible to distinguish the environment.

The use of the enclosed arc has become so common that the lamp need not be further considered here. Indeed, there is promise that it will be superseded by a newer type of arc-lamp hereafter described.

Luminous Arcs.—In an ordinary arc between carbon electrodes, the light comes from the tip of the incandescent electrodes, and comparatively none from the vapor stream itself. In the development of the new lamps it was attempted to increase the light-giving power of this non-luminous vapor by intro-

*See also "New Incandescent Lamps," in Technical Literature for September.

ducing some substance not carried by the common carbon electrodes. There are two ways of doing this: (1) by using in a direct-current lamp negative electrodes of a material whose vapor gives a highly-luminous spectrum; (2) by employing electrodes of such refractory materials as will give a very high arc temperature and cause to be fed into the arc vapor, by heat effects, materials which may be carried by the positive electrode, but which are not serviceable for the material of electrodes of the first class, though increasing the light-giving power of the vapor. Lamps working on the latter scheme are universally known as "flaming arcs," while those working on the first idea are variously called "metallic," "magnetite," "titanium," or even "luminous" arcs.

The Flaming Arc.—Carbon arcs have proven refractory enough to secure the temperature necessary for vaporizing the foreign substances which it was desired to introduce into the arc vapor to increase the light. If we have a carbon negative and a positive of carbon impregnated with or containing a core of calcium fluoride or borate, then the calcium vapor enters the arc vapor and is heated to the arc temperature, becoming highly luminous. Such material is preferably so fed in from the positive electrode, as this is the better. Here the efficiency of light production depends on the temperature of the positive electrode which controls the vaporization of the luminescing material. If the positive electrode is large and consumes but slowly, the efficiency decreases as the amounts of [illegible] Therefore a rapid [illegible] of the [illegible] [illegible] of [illegible] should [illegible] of [illegible].

As a type of these lamps those made on the Beck German patents may be briefly described. The electrodes of these lamps carry a rib or long fin, which supports the carbon, resting on a metal stop. As the carbon burns away the rib, of course, burns also, and the electrode feeds by gravity. The arc is drawn by a plunger disk, operated by a series magnet, which forces the electrode holders apart. This is shown in Fig. 1. In some lamps the

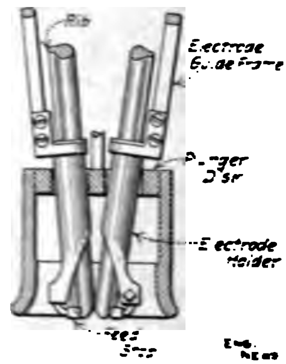


FIG. 1. LOWER MECHANISM OF FLAMING ARC LAMP, BECK FLAMING LAMP CO.

negative carbon alone rests against a stop, and the positive is suspended in its guide frame by a compensating chain attached to the negative, so that, as the latter burns away the positive also is lowered. In some forms, also, the rib on the carbon is absent. A starting resistance (or an inductance-coil in the alternating-current types), is included in the circuit to avoid a dead short circuit in starting. In some lamps magnetic blow-out coils with properly located cores repel the arc downward from the electrodes in a fan or [illegible]. In all these forms the mechanism is [illegible]. The general appearance of the [illegible] type is shown in Fig. [illegible] of the electrodes for all [illegible] necessarily small in or[illegible] luminous vapor may [illegible]. This, with the nec[illegible] makes the life of a [illegible] of from 8 to 17 hours. [illegible] possible with very long [illegible] [illegible] ations where their [illegible].

[illegible] give, at about [illegible] consumption, a mean [illegible] 850 to 1,100, a [illegible] 1,500 to 3,300, and a mean [illegible] spherical about 1,600

to 2,000 c. p. This yields a power consumption figure of about 0.7 to 0.4 watts per mean spherical candle, English Units.

Metallic-Arc Lamps.—The development employing negative electrodes made from materials giving a brilliant arc vapor seems to be

FIG. 2. GENERAL TYPE OF FLAMING ARC LAMP WITH CONVERGENT ELECTRODES; BECK FLAMING LAMP CO.

far less limited in field of application than the "flaming-arc" just described. The possibilities are so promising that it would not be surprising were the present common enclosed arc lamp for street uses, to a great measure, superseded by these lamps on account of somewhat higher efficiency and smaller maintenance expenses. A directly comparative and complete series of tests showing the relative utilities and efficiencies of the "metallic," "open" and "enclosed" types of arc lamps is not available, and only rather general comparisons can be made. Metallic arc lamps giving about 650 to 700 c. p. maximum on 310 watts energy supply, have been used to replace enclosed arc street arcs of 400 to 600 maximum c. p. on 480 watts, with improvement in the street illumination.

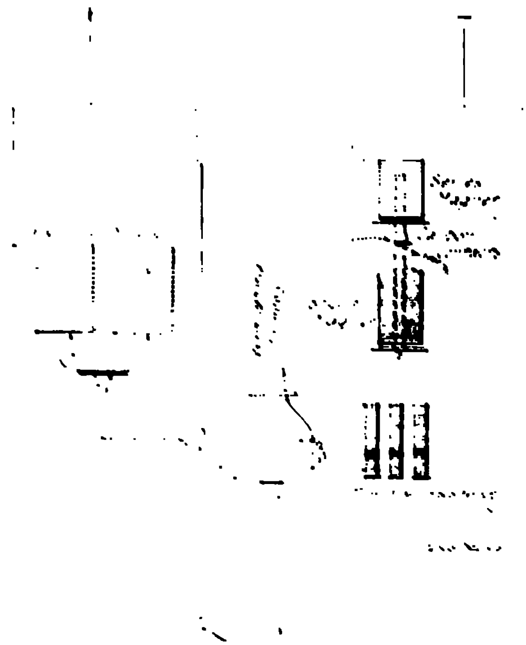
The manufacturers of arc lamps claim that the common demand is for street lamps giving a white light. Such a demand, at present, limits the use of substances available as negative electrodes to those whose vapor spectrum is fairly well distributed and whose light is necessarily "white." These substances are of the iron group—iron, titanium, tungsten. The range of substances is narrowed still further when the characteristics of the electrode are considered: (1) it must be a fair conductor, and (2) it must be long-lived. These necessitate the use of an oxide or a carbide. As these materials, after vaporization, redeposit as a solid, the lamp must be arranged as an "open" arc, with special ventilation.

The research of Dr. C. P. Steinmetz showed that magnetite or magnetic iron oxide (Fe_3O_4) was the most convenient and available basis for an electrode, though its light-giving quality was inferior. The addition of a certain amount of titanium oxide gives great brilliancy and efficiency to the arc. A certain predetermined amount of chromium oxide is added, which has the effect of restricting undue production of titanium vapor and consequently promotes a longer life of the electrodes, although at a slight sacrifice in the efficiency of light production.

The positive of this kind of lamp is a metal, usually copper or a copper alloy, which is consumed only very slowly. At first this may seem anomalous, but the explanation is simple. As this lamp arrangement is adapted only for direct current, the arc stream is always unidirectional and toward the positive electrode. No material is carried, therefore, from the positive by the arc-stream, and if the material and design is properly manipulated the heat at this positive will be transmitted and radiated as fast as developed. A slight coating of conductive slag also protects the hottest portion of the metallic surface from rapid oxidation.

Laboratory or experimental alternating current magnetite-arc lamps have been built. Magnetite, titanium and most other metal oxides are such electrode materials as require a sparking voltage, at the temperature of the

arc vapor, considerably in excess of that required to maintain an arc. This phenomenon was noted in the general discussion of arcs. On account of this characteristic of the direct current luminous arc electrode, they do



[illegible]

[illegible] until it touches the positive, when current must flow through the electrodes and the series cut-out magnet, as indicated by a glance at Fig. 3. This weakens the feeding magnets until the negative electrode falls, until supported by a clutch, thus drawing the arc. When the negative electrode is consumed so that the arc-voltage has reached a certain point the shunt-feeding magnet becomes strongly energized enough so that it closes the carbon contacts. The starting magnets are now again taking current and bringing the electrodes into con-

[illegible]

tact. The lamp will now repeat the first operation. This action also tends to break up any slag or crust formed about the edges of the negative electrode. It will be noted that here the use of air currents is utilized to carry off the light solid products of the arc and incidentally to steady and center the arc.

Without such a ventilating system the accu-

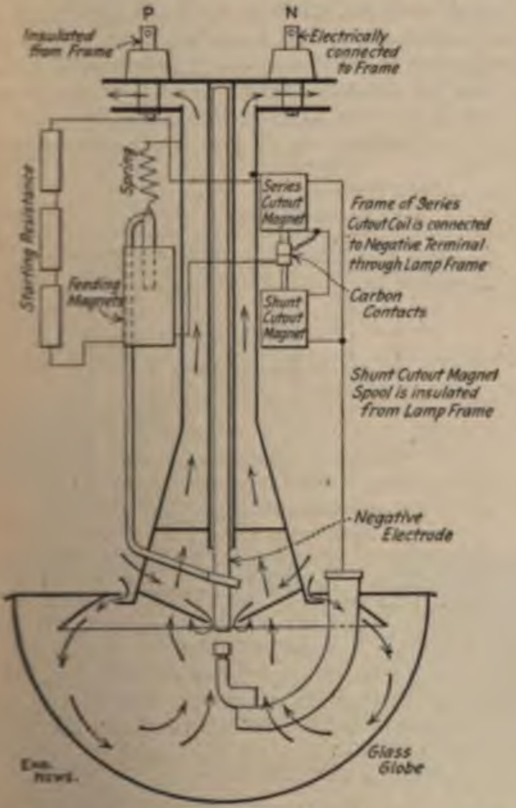


FIG. 5. DIAGRAMMATIC ARRANGEMENT OF THE PARTS, WESTINGHOUSE METALLIC ARC LAMP, SHOWING DIRECTION OF AIR CURRENTS.

mulation of these oxides is rapid and interferes with the proper distribution of light.

The brighter portion of the arc is near the negative electrode, and the makers of the overfeed type claim that the shadow under the underfeed lamp is larger and denser than when the electrode is fed from the top. This underfeed necessitates a larger globe and a thicker electrode or a shorter life than the upperfeed. With the overfeed lamp developed by the Westinghouse Co., the difficulty of the light oxide accumulating very rapidly has been obviated by arranging the ventilating system so that a current of air comes down around the negative electrode, and another scours over the reflector surface, and these both pass up a chimney, substantially as shown in the diagram, Fig. 5. It is stated that these air ducts have been carefully designed so that the highest winds cannot reduce or reverse the drafts. The steadying effect of these air currents makes it possible

FIG. 6. THE WESTINGHOUSE METALLIC ARC LAMP.

to maintain the arc voltage more uniform, thereby increasing the efficiency by reducing the average of watts consumed.

The general arrangement of the parts of the Westinghouse lamp are shown in Figs. 5 and 6. The electrodes, when the current is off, are separated, and the cut-out contacts are closed. The armature of the feeding magnet is connected to a dash-pot having a graphite self-lubricating plunger which is designed so as not to stick under the most severe conditions.

When the current is turned on it energizes the feeding magnets, which pull down their armature and bring the electrodes into con-

tact. This allows current to pass through the series magnet and the series cut-out is lifted from the shunt cut-out contact, thus breaking the circuit through the feeding magnets. Accordingly the armature is released and the arc is drawn. As the negative electrode burns away the arc lengthens and the voltage across its terminals rises until a sufficient current passes through the shunt magnet so that it raises the shunt cut-out contact until it touches the series contact. Then the feeder magnets are energized and the arc fed until its normal length is re-established.

Rectifier System.—Metallic-arc lamps were first operated by modifications of the old-style, series arc generators, notorious for their inefficiency. After considerable experimenting, mercury-arc rectifier sets were designed for furnishing the necessary direct current at constant amperage from constant-potential alternating-current supply. The set consists essentially of a constant-current transformer, a mercury rectifier, a switchboard, and necessary instruments, etc. The general arrangement is shown in the diagram by Fig. 7.

The constant-current transformers are, in general, the same as those developed for series alternating-current lighting systems. In the General Electric Co.'s system a reactance coil enclosed in the same case with the transformer is inserted in the direct-current circuit to reduce the pulsations in the rectified uni-directional current. Additional inductance also may be placed in the alternating current circuit of the rectifier tube to dampen "kicks" in that circuit due to line disturbances.

In this system a starting transformer is used to supply a low potential split-phase current to the starting anode of the mercury-arc rectifier. A small auxiliary arc is started which ionizes the vapor of the tube and allows the main arc to establish itself at once without the high voltage necessary to start the arc between the main electrodes.

In the Westinghouse [illegible] arc rectifier system [illegible] designed so that [illegible] in the windings [illegible] energy so that [illegible] ing direct current [illegible] [illegible] street lamps [illegible] transformer [illegible]

The [illegible]

This lamp has [illegible] introduction [illegible]

low operating cost, and the tubular form, with low intrinsic brilliancy and good diffusion, are of greater importance than having a natural color value of illumination.

The complete lamp for direct current comprises the tube and holder, and a small set of inductance and resistance coils connected in series with the tube. The tube is of a special glass, carrying an iron electrode at the upper or positive end, and a mercury electrode at the negative or bulb end, connected with the outside by platinum wires sealed in the glass. The tubes are made in lengths of 21 and 45 ins., of a diameter of 1 in. for candle powers

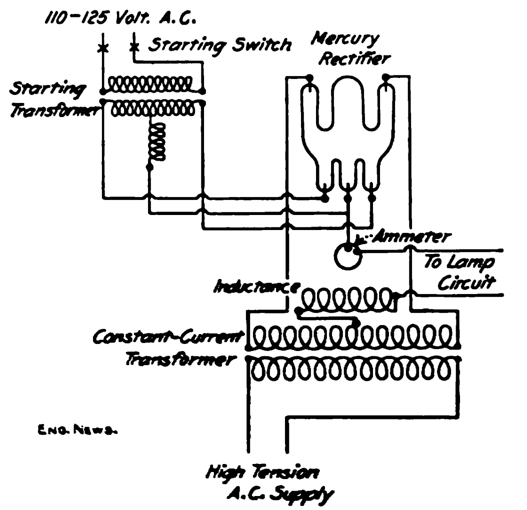


FIG. 7. DIAGRAM SHOWING GENERAL ARRANGEMENT OF MERCURY ARC RECTIFIER SYSTEM FOR SERIES METALLIC ARC LAMPS; GENERAL ELECTRIC CO.

of 300 and 700, respectively, for the general groups of voltages about 110 and 220, respectively. The tube can be adopted for any commercial voltage, though the candle power changes slightly for different voltages. Only a small quantity of mercury is contained in the bulb at the negative end. The tube is exhausted and sealed similar to Crookes vacuum tubes.

[illegible] is supported by two clamps, fast- [illegible] which is parallel to the [illegible] is pivoted to the main [illegible] into the ceiling crow- [illegible] etc. are also sup- [illegible] covered by a metal [illegible] a reflector is fastened [illegible] is shown by Fig. 10. [illegible] considered alone, has a [illegible] experiences

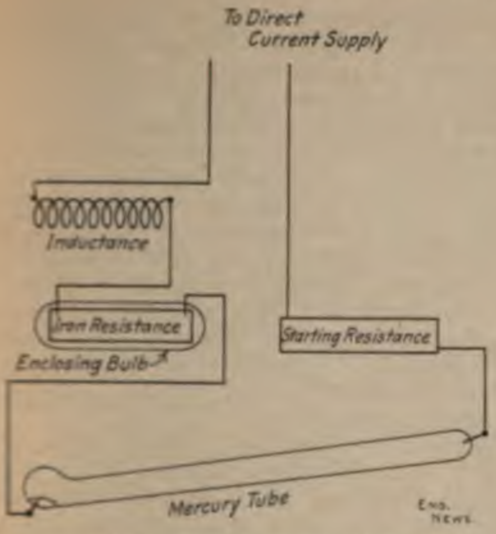


Fig. 8. For Direct Current Lamps.

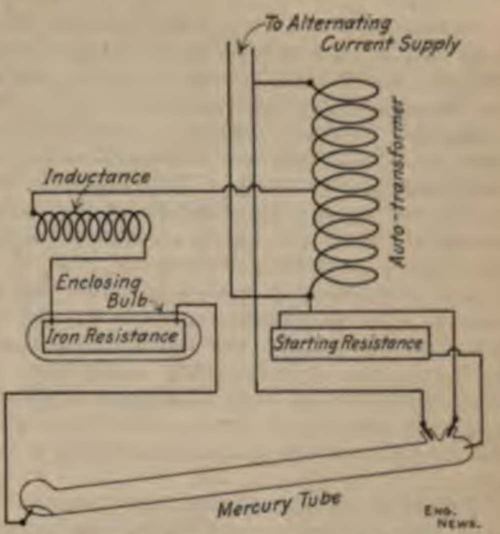


Fig. 9. For Alternating Current Lamps.

FIGS. 8 AND 9. DIAGRAMS SHOWING ARRANGEMENT OF PARTS OF MERCURY VAPOR LAMPS.

momentary increases of resistance of sufficient magnitude to break the continuity of the arc. This seems to disappear with a current of over four amperes, and with smaller currents when the negative electrode becomes hot. With the fect of increasing resistance tends to become cumulative, as a certain-sized inductance has been found to keep the vapor stream continuous for a few seconds, while a larger one would be necessary to maintain it for a few

FIG. 10. THE COOPER HEWITT DIRECT-CURRENT MERCURY ARC LAMP.

3.5-ampere lamp, the commercial type, it has been found necessary to introduce inductance in series with the tube so that the magnetic energy stored opposes and overcomes the tendency to reduce the current. This ef- minutes or an hour, and a still larger one for absolute continuity.

Roughly speaking, an increase of induction in the circuit of ten times lengthens continuity of action about 1,800 times.

In starting the tube is tilted and the mercury in the tube poured, in a small stream, between the two electrodes. A short circuit is prevented by an auxiliary resistance. When this stream is broken by returning the tube to normal the arc is started and the lamp put into operation. This tilting is accomplished by a chain attached to the upper end of the lamp rod, or by a solenoid on the stem at the pivot joint of the lamp rod.

It is impossible to work the simple direct-current tube on alternating currents on account of the phenomenon noted under alternating-current arcs, mercury being one of those electrode-materials with which the voltage consumed in an arc is much less than the sparking voltage at the temperature of the arc.

The tube for the alternating-current lamp is similar to the direct-current type, except that the upper end carries two positive electrodes and a small starting electrode (connected through resistance to one positive).

The starting is accomplished by tilting the tube by a chain. The mercury flows out of the bulb as in the direct-current type, and strikes the starting electrode, but skips the positive electrodes, which are in pockets on the upper half of the tube. On account of the irregular flow of the mercury about the starting electrode it makes and breaks the circuit, starting an arc. If the arc be started at such a point of the alternation of current that the mercury column is the negative electrode, then the arc will continue between the mercury and (alternately) the starting electrode and that positive to which the starting electrode is not connected. On account of the resistance connected between the temporarily inactive positive and the starting electrode the arc will not be maintained on the starter, but on both positive terminals alternately. If there were no resistance between the starting electrode and that positive electrode to which it is connected, supposing the arc to have just been started, and the tube still tilted, should the mercury touch the starting electrode again the arc would fail, as a metallic path would be placed in parallel with it.

As the candle power of the mercury arc varies considerably with variations of voltage, some auxiliary regulating apparatus needs to be included in the circuit. A "ballast" resistance has been provided, quite similar to that used with the Nernst lamp. An iron wire is wound on a porcelain pencil and the whole sealed in a glass tube through which the terminals pass. Iron has the property of greatly increasing its resistance by passage of relatively small current. At 500° C., the working temperature of the "ballast," this effect is enormously accentuated. The coil is placed in series with the arc, and is so designed that a slight decrease in the current causes such a decrease in the voltage drop across the terminals of the coil that the remaining portion of the voltage impressed on the lamp remains more nearly constant.

The mercury-arc lamp has found its widest application in various industrial and commercial plants. On account of the comparatively large candle powers and peculiar colors it is limited to such places.

Those who have not worked under the light are the strongest objectors to its green color. However, many manufacturers and shop operators state that workmen, clerks, and draftsmen, alike, soon become used to the absence of red rays and that the eyes apparently are less fatigued by the same length of time in close application to fine work than with those illuminants yielding more red rays.

The current consumption for a given amount of light is particularly economical with the use of the mercury lamps, being claimed to be about half that of open arcs, a third of the enclosed-arc figure, and a sixth of the common incandescent service. While the first cost is high, yet it may, under many conditions, be lower than the installation cost per candle power for incandescent service. This item of installation cost has varied from one-half to twice that of the other forms of electric lighting. However, the makers claim to be able in almost every case to guarantee that the reduced operating cost will be such as to pay the entire cost of installation on equipments of considerable size.

The life of the tubes is guaranteed for 2,000 hrs., and averages much above that, perhaps, about 5,000 hrs. Individual cases have run to 7,500 hrs.

The Moore Vacuum Tube.—Mr. [illegible]Farlane Moore began his work on commercializing Geissler tubes about twelve years ago. In the various stages of development the system has had different lengths, sizes and shapes of vacuum tubes and numerous devices for the production of the necessary high potential to make the tubes luminous.

In its present form the vacuum tube consists of a 1¾-in. glass tube for any desired length supported near the ceiling by suitable brackets and encircling the area to be il-

luminated. This continuous tube is made in place from 6 or 8-ft. lengths, joined with blow-pipes by methods made familiar by makers of physical apparatus. The ends of this long tube are brought to a steel box about 2 ft. square. Large carbon electrodes are inside each end of the tube, connected to the outside contacts by platinum sealed in the glass. The completed tube is exhausted in position by a portable mechanical vacuum pump to a pressure claimed to be about 1-40,000 of an atmosphere.

The necessary high tension current is obtained from a simple transformer, located in the steel box mentioned above. . .

It was early shown that, with such tubes, the rarefaction steadily increased, increasing the resistance in an obscure manner until it became too high for the working voltage. Consequently the light of the tube soon went out. This difficulty is at present overcome by a most ingenious regulating valve. A piece of ⅞-in. glass tubing is supported vertically, with its bottom contracted into a ⅜-in. glass tube, which extends to the main lighting tube. At the point of contraction a ¼-in. carbon plug is cemented in. Its porosity is such as to allow gases easily to percolate through, but not sufficient to allow the mercury which normally completely covers it to pass. Partly immersed in the mercury and concentric with the carbon plug is a smaller movable glass tube, whose upper part carries a bundle of soft iron wires, which form the core of a

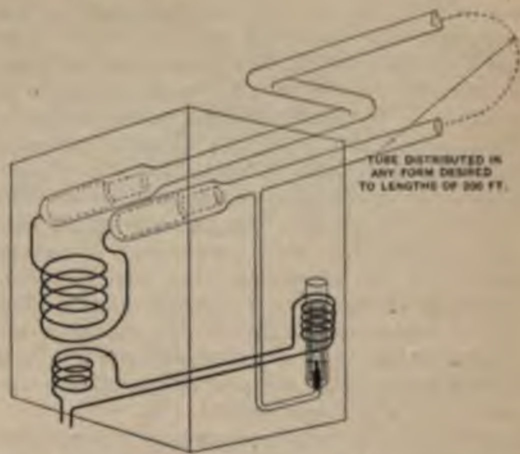


FIG. 11. DIAGRAM SHOWING ARRANGEMENT OF ESSENTIAL PARTS OF "MOORE LIGHT."

FIG. 12. TYPICAL INSTALLATION OF MOORE VACUUM TUBE, LOBBY OF MADISON SQUARE GARDEN, NEW YORK CITY.

solenoid in series with the primary of the transformer. All these parts are shown in the diagram, Fig. 11. There is a critical point of vacuum at which the conductivity is a maximum, and the tube normally works a little below this. As the vacuum becomes higher the conductivity increases and a greater current flows through the solenoid. This lifts the displacer, lowers the mercury level and exposes the carbon tip. Immediately a minute amount of gas passes into the vacuum tube, until the vacuum falls to normal and equilibrium is established again. This action is repeated about once a minute during the use of the tube. This feature of the Moore apparatus is also shown in Fig. 11.

When the regulating valve is arranged to admit air, the light given by the tube is rose-colored. If nitrogen is used the light is yellow, and when carbon dioxide is admitted a close imitation of daylight color values is obtained. It should be stated that the tube giving "white" light is not as efficient in light production as when air is admitted.

Tests by the New York Electrical Testing Laboratories have shown an efficiency of 0.65 watts per c. p. for the rose-colored tubes; with those for the production of white light the efficiency is about 1.5 watts per c. p.

The advantages of the light may be briefly presented: A low intrinsic brilliancy of about 12 c. p. per lin. ft. of tube; a better efficiency than carbon filament lamps; a good diffusion, but not entire elimination of shadows. Its disadvantages lie in present difficulties of repair, high initial cost and lack of flexibility.

BLAST-FURNACE SLAG CEMENT

By HORACE ALLEN

FROM "THE IRON TRADE REVIEW"

In the direction of utilization of the by-product slag various more or less satisfactory methods have been devised, such as the manufacture of paving blocks, artificial stone, concrete flags, slag cement, slag sand, slag bricks, slag mortar, slag wool; but owing to the large quantities produced, the most economical and profitable methods of utilization are those which can be made to deal with the whole of the slag. In any of the applications of slag instanced above only a comparatively small proportion of slag produced can be turned to profitable account, and as the slag continues to accumulate, it must either be dumped upon land at an expense for haulage and rent, or carried to some free deposit at the cost of carriage, etc. In some local cases instead of having to incur expense, a small price is paid for the slag for road making, etc., and this is probably the most profitable, if the whole of the slag can be disposed of; the other applications, while bringing in a return, can chiefly be said to offset the cost of dealing with the bulk produced.

In regard to the utilization of blast-furnace slag for the manufacture of Portland cement, it must be borne in mind that, without careful analytical selection, combined with calcination, the slag will only form a substitute for the usual addition of sand in cement mixture. Regardless of the claims of inventors crude slag, however finely ground only forms the nucleus for the active cement to combine with. The writer has made a special study of this question and cannot too strongly advise managers to carefully scrutinize the claims of any advocate for the employment of slag for a substitute for Portland cement. The cost of grinding to the necessary fineness must also be taken into consideration.

Instead of calculating upon the value of the prepared slag at the price of real cement, the real value here is on the sand usually mixed with cement in structural employment, unless it is used in admixture with cement clinker and subjected to calcination. The above remarks do not refer to slag cement and mortar, both of which may be of fairly good quality, but fall short of Portland cement. Certain classes of blast furnace slag can be utilized in the manufacture of Portland cement, as already indicated, and considerable quantities are employed in the

building of docks, breakwaters, foundations, etc., and the following particulars may be of service in this connection:

Tri-calcium silicate:

Formula	Ratio of CaO to SiO_2	Per cent. CaO	SiO_2
3 CaO SiO_2	2.8	43.68	26.32

This is constant in volume and hardens well, though slowly, but 3½ CaO to 1 SiO_2 is not sound.

Di-calcium aluminate:

Formula	Ratio of CaO to Al_2O_3	Per cent. CaO	Al_2O_3
2 CaO Al_2O_3	1.1	52.38	44.62

sets quickly with good hardening properties and constant volume; while 2½ CaO to 1 Al_2O_3 does not give a sound result.

The writer considers that the following formula should be approximated in percentage proportions:

$$CaO = (SiO_2 \times 1.86 \text{ to } 2.8) + (Al_2O_3 \times 1.1 \text{ to } 1.64)$$

But the chemical analysis is of little service in determining the quality of the cement in the absence of particulars of manufacture and physical tests. The content of lime in good cement ranges up to 66 per cent.; magnesia may be up to 2 per cent., but not higher.

Flour is most suitable when the cement is to be mixed with sand, but if the cement is to be used neat it should be of a rougher quality. The chemical constitution of Portland cement of good setting quality must in its chief constituents be within the

Lime (CaO)	............47 to 60	per cent.
Silica (SiO_2)	...........20 to 35	per cent.
Alumina (Al_2O_3)	.... 5 to 15	per cent.
Magnesia (MgO)	less than 3	per cent.

From the above, it will be evident that slag containing a higher proportion of magnesia than 3 per cent, must be used very sparingly in admixture with cement clinker to keep the proportion of magnesia within the limit given, and the proportion of sulphur, or sulphuric acid, must be kept low, if good, sound results are required.

A rough calculation shows that the total weight of cement exported from England and Europe to oversea countries only amounts to about 1-25 of the slag produced in the United States alone.

VALVE LEAKAGE

FROM "THE ENGINEER," LONDON

We recently referred to a paper by Dr. Mellanby on "Superheated Steam," in the course of which he spoke of the theory advanced by Messrs. Callendar and Nicolson to account for what is known as the "missing quantity" in steam engine cylinders—in other words, to explain that disparity which exists between the weight of the feed-water pumped into a boiler and that measured by the indicator. The accepted theory up to 1897 was that the metal of the cylinder, being cooled down during the exhaust period, condensed steam when the admission port opened, which steam was not wholly revaporized during expansion. Briefly loss was due to initial condensation. Messrs. Callendar and Nicolson made experiments and calculations to determine the precise quantity thus condensed under any given circumstances, and arrived at the conclusion that initial condensation could only represent a very small portion of the loss. That a very considerable loss did take place was indisputable, only one way remained of accounting for it. The piston of the experimental engine was found tight; leakage past the slide valve alone remained as a cause. But when the engine was standing, the valve was tight. Therefore the loss must be due to the movement of the valve. The ultimate shape taken by this theory is that steam passes the slide valve in the form of water.

Engineers have, as a rule, hitherto paid very small attention to Messrs. Callendar and Nicolson's views. This is to be regretted, and Dr. Mellanby has done good service in putting them forward once more for discussion. At least one curious question is raised, namely, the behavior of steam when leaking between comparatively large flat surfaces. It seems to be certain that, under these conditions, liquefaction does take place. Water drains away at all events. There is no reason to think that this is due to cooling in any ordinary sense. The only possible explanation is that the heat is converted into work. So much energy is expended in forcing the steam through the "chink" that liquefaction ensues. If this is not

what happens, we are left without an adequate explanation of any kind. If it does happen, it is not quite easy to explain what becomes of the heat. It is to be assumed that it is spent in overcoming fluid friction; but the quantity is so considerable that tangible evidence in the shape of a rise in temperature somewhere ought to be afforded. Thus, an engine of 100 indicated horsepower using 2,000 lbs. of steam per hour may very easily have a missing quantity of, say, 8 lbs. per minute. If the total pressure is 115 lbs. the temperature will be 338°; the total heat will be 1,184.5. One pound condensed to water at 212° will, liberate, say, 972.5 units. The heat loss to be accounted for will, therefore, be 7,780 units per minute. No one has, so far, attempted to say precisely what becomes of this heat. Those engaged in research work might do good service if they would carry out some direct experiments which would tell us what takes place when leakage goes on between two plates working under varying slide-valve conditions.

Another way of accounting for the missing quantity is based on the assumption that whenever steam in motion is suddenly arrested a part of it is condensed. It is not necessary to go here minutely into the reasons assigned for this. It is enough to point out that certain molecules possessing a motion proper to the condition known as steam lose that motion by coming into sudden contact with a resistance. So-called separators may, it is said, produce the greater part of the water they are supposed to remove; and we have heard it stated that if separators are used in series each of them will produce water. It does not appear to us, however, that there is any necessity for calling in the aid of recondite theories such as this to account for the missing quantity. In the first place, condensation due to radiation and conduction is always going on when the engine is at work; and it has yet to be proved, in the next place, that distribution sliding valves may pass to waste as much as [illegible] of all the steam sent into an engine, or that the range of temperature in the cylinder is not sufficient to account for the loss. Two prominent facts should be kept in mind. In the triple-expansion engines the high-pressure cylinder almost always works wet. Again the low-pressure cylinder always works dry. We advance no explanations. The facts are well known to all sea-going engineers, and they seem to us to have a bearing on the valve leakage theory. It will scarcely do to say that the high-pressure valves are more likely to leak than the low. The difference in pressure at the two sides of the leak must be kept in mind. The high-pressure valve is not leaking into a vacuum, but into the first intermediate receiver.

Turning now to the temperature of the cylinder walls, it will be seen on reflection that the surface in the clearance space is so large that the raising of the merest film of metal from the temperature of the exhaust to that of the entering steam will suffice to condense quite considerable quantities of steam. We have already pointed out that the late Bryan Donkin carried out most elaborate experiments to ascertain the fluctations of temperature in this "skin" surface without ever arriving at any conclusion which wholly satisfied him. One difficulty is in getting a thermometer which will act quickly enough. He tried a Thermopile, but he abandoned it as a failure. In 1905 Dr. Mellanby read a most exhaustive and thoroughly excellent paper on "Steam Jacketing" before the Institution of Mechanical Engineers during the Liège meeting. That paper contains a diagram showing how the temperature of the cylinder walls of the engine with which experiments were made had been measured. But the thermometer bulbs were separated from the inner surface by a thickness of metal of ⅝ in., and the temperature range of the metal was calculated, not directly measured. Keeping all the facts in mind, it must be admitted, we think, that the present position of the whole question is very unsatisfactory. If it can be proved that all the benefits of superheating and compounding and jacketing, as far at least as economy of fuel is concerned, can be secured by the simple expedient of making distributing valves steam-tight, the gain will be enormous. Yet the proposition has been before the world for nearly 10 years, and still engineers as a body are wholly incredulous. That Dr. Mellanby himself always qualifies the argument advanced by Messrs. Callendar and Nicolson with an "if" is, we think, no reason for refusing to inquire further into the merits of a scheme which promises so much. The results obtained with the piston drop valve seem to favor the theory. [illegible] to be impossible to make an engine with valves quite tight, at least for a time, and to carry out with it very simple experiments which would go far to settle once for all whether valve leakage can or cannot account for the missing quantity." Failing such an experiment we may go on talking and writing forever without arriving at a really contenting conclusion.

LONG KEY VIADUCT OR CONCRETE VIADUCT, LOOKING FROM LONG KEY.

CONCRETE VIADUCT CONSTRUCTION AT SEA

By M. B. CLAUSSEN

FROM "CEMENT AGE."*

oncrete plays the most important part in construction of the Florida East Coast lway Extension from Miami to Key West. hundred and fifty-six miles is the distance ween these points. Key West, the most therly city of the United States, lies at the terly end of a chain of islands or keys, a ointed continuation of Florida's east coast. ty-two keys and seventy-five miles of water have to be crossed before the first train steam over the waves and enter Key West.

his novel piece of construction will come the life work of Mr. Henry M. Flagler, for the past twenty-three years has been tinuously developing Florida's east coast. ing transformed the semi-tropical jungle a garden spot where thousands of tour flock in the winter, he has turned his eyes the sea, that turbulent body of water rating and making islands of the Florida ys.

he intervening water between the forty keys varies in width from a few hundred 15,100 ft., and in depth from one to thirty t. In the shallow and protected portions e dredges are constructing embankments m key to key. These will be rip-rapped h rock to prevent washing and make a perent structure. The roadbed across the keys is nearly completed, and construction trains run over seventy miles of track.

By far the most important part of this wonderful undertaking is the six miles of concrete viaducts that span the deeper and more exposed waters of the Gulf and Ocean. The first of these viaducts, of which there are four, commences at the westerly end of Long Key. When completed it will have a total length of 10,500 ft., and consist of 184 arches of 50-ft. centers, except every fifth arch, which will have a 60-ft. center in order to take up the "lean." The water varies in depth from thirteen to twenty feet between these Keys, and the tide under normal conditions flows at the rate of four miles an hour. In order to place the roadbed out of reach of the highest waves, the top of the viaduct is carried to a height of 31 ft. above high water.

While 286,000 bbls. of cement, 177,000 cu. yds. of crushed rock, 106,000 cu. yds. of sand, 612,000 lin. ft. of piling, 5,700 tons of reinforcing rods, and 3,600,000 ft. of dressed lumber for arch forms will be used in constructing the six miles of ocean-going viaducts, a description of the work now under way on the Long Key viaduct will give one an idea of the magnitude of Mr. Flagler's undertaking.

Five hundred of the 2,500 men engaged on the whole work are comfortably housed in a permanent camp on the westerly end of Long

*We are indebted to the courtesy of this journal for use of the original illustrations.

Key. They are divided into two shifts of 250 men each, for work continues all night under the glare of thousands of electric lights. Seventy of the 186 arches are completed. The method of construction is as follows:

Pile drivers drive 28 piles into the coralline limestone rock which forms the bed of the ocean at this point. After the pile drivers pass on to the site of the next pier, a cofferdam is lowered from a giant catamaran into place around the piles. By means of a long pipe that extends to the bottom of the cofferdam, a ceiling of concrete is laid to a depth of 3 ft. When this hardens the water is pumped out and the pier forms set in place around the piles that have previously been cut to low-water mark.

The catamaran now passes on to the next set of piles, its place being taken by a mixing machine with its accompanying barges loaded with cement, crushed rock, sand, reinforcing rods and tanks of fresh water. Salt water is not used on account of its deteriorating effect on the steel reinforcing rods. The mixing machine is provided with two sets of steam derricks, one to collect the different ingredients and deposit them in the mixer, while the other transfers the concrete to the forms. Reinforcing rods are wired in place, and the pier form filled with concrete, hermetically sealing the piling. The pier forms are left in place for three weeks.

Where the water is over 13 ft. in depth the piers are stepped out, the top of step 12 ft. below the springing line. This line is below mean low-water level. The ratio of the steps for the 12-ft. piers is one horizontal to three vertical, the 9-ft. piers have one horizontal and four vertical. In places where the rock is too hard for pile driving, an excavation will be made to a depth of two feet, and the base of the pier securely anchored therein.

On a float just wide enough to permit its passage between two piers, is the arch form. The float is now towed into place. By means of jacks the form is lowered till it rests in its proper place on the piers. The spandrel wall forms,.made up of several sections, are now set in place. Both arch and walls are reinforced with corrugated bars. Reinforcing rods in the arch are connected in one long piece by means of welded links and wedges. Cross-rods are now wired into place, their ends entering and forming part of the spandrel wall reinforcing plan.

After they have passed on the construction of the forms, two giant mixing machines with their barges are warped in place along side. Concrete is rapidly deposited in the forms where it is tamped by the construction gang. The arch and spandrel-wall forms are left in place for three or four weeks. So well are the forms made and the work done that no pointing-up is necessary when the forms are removed.

Seventy of the 184 arches in this viaduct have been constructed, and the work is progressing at the rate of one arch or 50 feet a day, (20 hours).

Concrete is used in many other ways through the work, but the construction of this sea-going ocean viaduct is by far the most interesting.

ON THE TOP OF THE VIADUCT. THIS WILL BE FILLED WITH ROCK AND EARTH.

HOW THE ARCH FORMS ARE CONSTRUCTED.

THE PIERS. NOTE REINFORCING RODS, PIER FORMS AND COFFERDAMS

MIXING-BARGE AT TAVERNIER CREEK, F. E. C. RY. EXTENSION.

IRON INTERLOCKING DAM USED IN CONSTRUCTING THE ABUTMENTS OF TAVERNIER CREEK BRIDGE.

Ǝ ENERGY PROBLEM OF THE UNIVERSE

By A. H. GIBSON

CONDENSED FROM "CASSIER'S MAGAZINE."

re considering what may in the future the sources of energy most suitable lization in all, or in some particular t would be well to examine the present sources, with a view to noting the ex- which they have been drawn upon in t; their present possibilities; and the od of their satisfying our future needs. ecting (as being at present outside the ven of prophecy) the fascinating pos- s of radium as a source from which ost inexhaustible supply of energy may ined, we note that the energy of the e, as available on earth, may be classified under four heads.

nergy leaving the sun and reaching th as radiant heat and as light—un-

eat energy stored in the earth, and e because of the high temperature of rior.

e kinetic energy possessed by the n virtue of its diurnal rotation, and of advantage may be directly taken by g the rise and fall of the tides as a of energy.

e energy which may be liberated chemical combination takes place be- the various elements or compounds to d in the earth.

energy of rivers and waterfalls being ailable in virtue of the reevaporation r which has reached the sea, may be red as coming under heading 1, while rgy of the wind may be considered as under headings 1 and 3, the current eing due, partly to the sun's heat, and o the earth's rotation.

radiant energy of the sun has been in t and must always be, indirectly per- he chief source of terrestrial energy, ng as it does the heat and light neces- all plant and animal life; and to this ll energy now stored in the coal fields roleum deposits must be attributed to use. In primordial days, then, this was the ultimate source of all energy available by mankind.

The direct utilization of this radiant energy as a source of power is, however, a different matter. It has been attempted by several investors, with some measure of success, particularly in California, where, by using huge parabolic reflectors driven by clockwork so as to have their axes always pointing towards the sun, and each carrying a steam boiler at its focus, power has been obtained; an installation fitted with a reflector of 33 ft. 6 ins. diameter developing just over 2 HP. under favorable conditions. By using the engine to charge an accumulator or to pump water into an elevated reservoir, a fairly steady supply of energy may be obtained in suitable weather.

The results of repeated experiments with similar apparatus show that, between the equator and latitudes 45 degrees N. and S., with a clear sky, quite 3.5 British thermal units per minute can be obtained for 9 hours per day for each square foot of projected area perpendicular to the sun's rays. Could all this heat be utilized, this would give 8.2 HP. for each 100 sq. ft. of projected area, but, due to the thermodynamic inefficiency of the prime mover only about 12% of this, or about 1 HP. for each 100 sq. ft. of surface, is available as indicated work in the engine cylinder.

The disadvantages inseparable from the utilization of this source of energy on any but the smallest scale are very great, both on account of the initial high cost of installation and of maintenance. These must always be high, since climatic and meteorological conditions prevent the installation of single plant of more than moderate size, and comparatively small power. Again, those parts of the earth's surface where a fairly steady supply of such energy could be relied upon, are, on account of their excessive heat, and their freedom from rain, quite unsuitable for the maintenance of any large centers of industry, while in temperate climates, or in subtropical climes

where the rainy season may cause a total stoppage of the power supply for some months on end, the method is obviously impossible. On these several counts it would appear that not until every other practicable source of energy has been tapped, will the direct utilization of the sun's radiant energy be carried out on any large scale. With the improvement of high tension transmission of electricity, for long distances, however, the idea of a series of power stations stretching along the southern coast of the Mediterranean, and along both sides of the Nile Valley, as well as along the shores of the Red Sea and supplying power through high tension transmission lines to centers of industry in Upper Egypt and Southern Europe, becomes more feasible. Taking an available area of say 20,000 square miles, and assuming 25% of this area to be usefully applied to the abstraction of solar energy, there would be available, on the basis of one horse-power per 100 sq. ft. of surface, no less than 150 million horse-power for 9 hours a day, an amount of energy which, when taken along with that from other subsidiary sources, would go far towards satisfying the entire power demand of the world.

Considering next the energy stored in the earth, in virtue of the difference in temperature between its interior and its surface, no attempt has yet been made to take advantage of this on any large scale, and it would appear on examination that this source of energy, though at first sight most promising, must be definitely acknowledged as being of no avail in solving the future power-problem. It is true that at isolated points of the earth's surface—notably in the Yellowstone Park in the United States of America, and in Iceland, as well as in the northern districts of New Zealand, abundance of water at a temperature of say 200° F. is brought to the surface by hot springs and geysers, and in close proximity to water supplies at a much lower temperature, say 60° F., and in these few instances there is no reason why this difference in temperature, though too small to allow of an engine using steam as its motive fluid to be used, should not be utilized to work a motor using either vapor or carbonic acid gas, the boiler being heated by the hot water supply, while the condenser is cooled by the adjoining cold supply. But these are only isolated cases. Normally, after a depth of about 100 ft. is reached, the increase in temperature as the earth's center is approached, is found to be at the rate of about 1° F. for each 60 ft. in depth, this temperature gradient increasing slightly with the depth. Until the former depth is attained the annual fluctuations of temperature are still felt. It would thus be necessary to sink a bore-hole to a depth of 6,000 yards to reach a point whose temperature was say 380° F.

In favorable localities, in the neighborhood of volcanoes, or where the earth's crust is known to be thin, this depth would of course be considerably reduced, but unfortunately such localities, on account of the probabilities of earthquake shock, and of volcanic eruption, are not exactly advisable places for the establishment of large centers of population or of industry. Could a supply of cold water then be introduced by one bore-hole into a large natural or artificial cavity at this depth and led away at a higher temperature through a second bore-hole, these two water supplies might be utilized as before, for the working of either ether vapor or carbonic acid engines. But, assuming this temperature at the base of the bore-hole to be initially attained, directly the flow of water commenced, the temperature would be lowered, and finally, when a steady state was attained, only as much heat would be given to the water as could be transmitted by conduction through that portion of the earth's strata in contact with the water. Assuming, when this steady state was reached, a temperature gradient of so much as 1° F. for 10 ft., we should get a supply of heat by conduction of about 0.12 B. T. U. per square foot of surface per hour and thus a cavity whose internal area was 237,000 sq. yds. or say 260 yds. in diameter, would be needed to give a supply of heat, equivalent—with a perfect engine—to 100 HP.—giving, with the engine in use probably about 10 HP., certainly an inadequate return for the energy expended in sinking the bore-holes alone. Here, too, the excess of the loss of heat by conduction from the surface of the ascending bore-hole, over the gain by conduction from that of the descending bore-hole has been neglected, though this would probably reduce the available energy by one-third, the issuing temperature of the water probably not exceeding 200° F. From this it would appear that, except possibly in the few localities before mentioned, the direct utilization of this energy is quite impracticable on any commercial scale. It must not be lost sight of, however, that in virtue of its conduction to the earth's surface, this energy is being continually utilized in the production

›dstuffs and so must always play a large in the energy scheme of the big globe.

›nsidering the next energy of the winds, ›e that this is useful for small powers ›or work in which regularity of working ›t essential, such as for pumping and ›age operations, flour milling, etc. Yet ›rge powers the installation becomes un›y and expensive, out of all proportion to ›turn. The further fact that this source ›ergy cannot be depended upon, and the ›ilties in storing energy so irregularly ›ced, effectively militate against the uti›on of this source of energy on any large

› the other hand, waterfalls and rivers › a source of energy which is equally ›le for large or small powers, and is suit› for all purposes, being steady, continu›and not involving great expense for ma›ry and appliances. Undoubtedly this › in the not distant future, become per›the second most important source of the ›'s energy, and indeed probably the next ›years will see the harnessing of every ›ct of any size, whether near or remote ›the industrial haunts of men, the energy ›tained being electrically transmitted to ›earest center of industry if not actually ›ed on the spot.

›s points to the ever-increasing develop›and use of the turbine as a prime mover, ›andard type probably, on account of its ›advantages and high efficiency, develop›ither on the lines of the Francis inward ›turbine, or, for specially high heads, on ›nes of the tangential impulse, or Pelton ›.

› next source of energy to be considered ›t due to the earth's diurnal rotation › its own axis. In virtue of this we have › up kinetic energy whose amount at ›resent is in the neighborhood of 3.7 × ›oot-pounds, but of which we can only ›ctly avail ourselves. The effect of this ›on, combined with the gravitational ef›of sun, earth, and moon, is to produce ›twice daily in the various bodies of wa›istributed over the earth's surface. If ›nsiderable mass of this water can be en›ed at high tide, and allowed to escape ›gh turbines or any other form of hy›ic motor, as the tide ebbs, evidently the › is indirectly due to the earth's rotation, ›will, if sufficiently great, have ultimately ›ppreciable effect in reducing the velocity › earth's rotation, i. e., in increasing the length of the sidereal day. Since, however, the length of the day would only be increased by a fractional part of a second by the continuous abstraction of an amount of energy equivalent to ten million horse-power for a million years, there would appear to be small reason for considering the effect of this on posterity.

The utilization of this energy may be carried out in two or three ways. For example, during the flow of the tide, water might be allowed to fill a large basin excavated to low-water level, this water being allowed to flow through a series of turbines as the tide-water thus impounded ebbs.

This might be done in either of two ways. The whole of the water might be stored until say one hour before low tide, and then be allowed to do the whole of its work during the next hour, the turbines thus working under a variable head having a mean value of about (H/2) feet, where H is the total tidal range. The whole of this energy would then need to be stored by accumulator until required. A second and preferable method consists in allowing the turbines to work under an approximately constant head of say 3 ft., the water being allowed to flow as soon as the level in the storage tank is 3 ft. above that of the ebbing tide.

Assuming a mean tidal range of 20 ft., in this case the level in the storage tank could only be allowed to fall through about 17 ft., and the work done, with a given area of storage tank, would be only about one-third that done in the previous case, though, owing to the time occupied in developing this power being about 5 hours as against 1 hour in the former case, the capacity for storage could be considerably reduced.

In addition, too, the fact of working at constant head would greatly simplify the problem of regulation and would tend to greater efficiency of working.

With an installation worked in this manner power would be directly available from the turbines for two stretches of 4½ hours each daily, at intervals of about 8 hours, and obviously as these slack intervals will overlap the working time to a greater or less extent, a storage system would be necessary, capable of dealing with the worst combination of circumstances which might arise, and capable of carrying, say 85% of the half daily output.

With a duplicate system of turbines, arranged to work under a constant head, one system being driven by the ingoing tidal wa-

ter, and the second system, as before, by the outgoing water, the work done by the water per day would be practically doubled, and it would now be possible to get useful work delivered from one or the other series of turbines for four intervals daily, each of about 4½ hours' duration, and separated by idle intervals of about 2 hours. In this case, the capacity of the storage plant needed would only have to be sufficiently great to carry the plant over a two hours' period, or about 25% of that needed in the previous case.

This necessity for cumbrous storage systems forms the main drawback to either of the foregoing schemes. The necessity may, however, be obviated by the provision of duplicate basins divided by a bank in which the turbines are placed. If now the upper basin communicates with the sea during the higher third of the tidal range while the tide is rising, and if the lower basin communicates with the sea during the lower third of the range while the tide is falling, the upper level never being permitted to fall below ⅔ H., and the lower level never to rise above ⅓ H., the available head, at all stages of the tide, varies between about 0.53 H and 0.80 H, having a mean value of about ⅔ H.

If the area of each basin be A square feet, a volume of water equal to (AH/3) cubic feet may thus be allowed to pass the turbines in 8⅓ hours, and, assuming a mean head of 20 ft., and a turbine efficiency of 75%, this gives

$$\frac{AH}{3} \times 62.4 \times \frac{2H}{3} \times \frac{.75}{33{,}000 \times 60 \times 8.33}$$

$= 6.3 \times 10^{-7}\ AH^2$ horse-power.

If $A_1' =$ area in acres, this becomes:—

$.0274\ A_1H^2$ horse-power.

This might be increased by possibly 30% by allowing a variation of level in the storage tanks equal H/2, but the advantage would be largely counteracted by the necessity for larger and more costly turbines, and by the greater difficulties in successfully regulating the speed.

In a scheme to be worked on these lines on the estuary of the Seine near Honfleur, the cost of special works necessary, not including the external training walls, which were necessary in any case for the improvement of the course of the river, worked out at £72,000, basins having a total area of 25,000 acres being inclosed. The tidal range being between 10 and 16 ft., this gives an available horsepower of 3,400 at neap tides and 8,800 at spring tides, or, taking the smaller value as being constantly available, gave a capital cost of £21 per horse-power developed at the turbine shaft. On the mean power developed the cost becomes £11.8 per horse-power developed. It would appear then that since the mechanical difficulties in the way are not very great, and since the financial side of the question is favorable even with coal at its present price, this method of utilizing the energy of the tides is not only feasible but most promising for the future, giving, as it does, an almost inexhaustible supply of energy, with absolute constancy.

Attempts have been made by numerous inventors to devise some means of utilizing the vertical rise and fall of the water in forming waves, and the energy contained in the water due to that motion, to perform useful work, and on a small scale several methods are feasible.

But on account of the variability and irregularity of the energy supply, and from the very nature of the case, it is evidently impossible that this source of energy can ever be utilized on any commercial scale.

Coming at last to the fourth, and most generally used source of energy, that of chemical combination, as exemplified in the combination of carbon and of hydrogen with oxygen, it is at once apparent that the more important of these sources of energy, the coal and petroleum deposits of the world, can remain available only for a further comparatively short period, as geological periods go, in the earth's history, and that as regards the distant future, they may at once be dismissed. Probably within the next 250 years the cost of coal will have increased to such an extent as to make the general utilization of some other source of energy essential. At present, however, it is, and in the near future is likely to remain, the most important source of energy for all motive purposes, and on this account it is worth while considering how its energy has in the past, is at present being, and in the future is likely to be most generally utilized.

In the past, practically the only method of utilizing this energy was in the production of steam, and it is interesting to trace the form of prime mover used for the transformation of the energy of this steam, in its slow development from the old reaction wheel of Hero and the water lifter of Savery, the atmospheric engine of Newcomen with the slow speed engine driving a rotating crank, the

high-speed Corliss engine of today, still the most efficient of all prime movers using steam as the motive fluid, and finally the steam turbine.

The steam turbine, in its most recent form, seems an almost ideal form of prime mover for the use of steam, because of its simple construction, the small space occupied, and, considering its comparatively recent development, its economy of working. Considering, too, the relative merits of turbines of the Parsons type and of the Curtis and deLaval types, it would appear that the advantages of the latter types, advantages due to better possibilities of governing economically under varying loads, to absence of "cylinder condensation," to reduction of weight of rotating parts, and generally to simplification of construction, will lead to a modification of one of these being finally adopted as the standard designs of the future, rather than that of the Parsons type.

But unfortunately all prime movers having steam as a motive fluid suffer from the common disadvantage that, in the production of this steam from water very great and unavoidable losses occur, while further and even greater losses occur in the transformation of this energy into useful work, only about 12% of the energy available in the fuel being available as useful work. In virtue of this consideration, it would appear at once that since the available store of energy accumulated in the form of fuel suitable for steam raising is so strictly limited, the steam engine, whether reciprocating or rotary, cannot, unless its efficiency be enormously increased in some way, hope to exist as a prime mover, unless, indeed, some other method of steam production is adopted. Now natural fundamental laws, together with the fact that the materials of construction at our disposal are not capable of being used at a very high temperature when in contact with steam, practically limit the possible thermal efficiency of a steam engine to about 65%, while consideration of maintenance, lubrication, etc., limit this to about 50%. But between this and the efficiency actually obtained in practice, there is a great gulf fixed, a gulf, the bridging of which in theory is fairly well understood, but which is in practice impossible.

Turning from this to the consideration of the internal-combustion engine, we find many obvious advantages, and, in view of these, it is not surprising that of late years so much attention has been devoted to the development of this type of prime mover.

Here many of the losses and inconveniences inseparable from the use of boiler or separate steam generator are abolished, the furnace itself forms part of the cylinder, and losses of heat by radiation from boiler casing, from steam pipes—and along with flue gases are done away with. The heat is generated just where it is required, its rate of generation can be exactly regulated, and in practice this type of motor is found to be rather more economical and more efficient than the steam engine or steam turbine. This is due largely to the fact that the motive fluid, being a gas and not a vapor, does not liquify on being cooled, and that on this account the losses of heat due to initial condensation in the steam engine cylinder, are obviated. The higher temperature limit of the internal-combustion engine cycle is conducive of more efficient working; but here again, a limit in this direction is early reached, due to the impossibility of constructing a reciprocating engine which shall work satisfactorily without lubrication and at a very high temperature. This necessitates water jackets, and a consequent direct loss of some 33% of the heat generated. Also the motor suffers from the necessity for changing reciprocating into circular motion, just as does the steam engine.

However, the balance of advantages pertaining to the internal combustion motor, whether using petrol, paraffin, alcohol, or gaseous fuel, blast furnace or producer gas, is such as to lead us to expect that the prime mover of the immediate future will be one having internal combustion, without the corresponding disadvantages consistent with reciprocating motion, and will be a machine of the turbine type.

It remains to consider, then, what must be the essentials of a satisfactory motor of this type.

A turbine of the Parsons or impulse type might be used, taking a charge of liquid or gaseous fuel, compressing and exploding this, using the high pressure gas thus obtained as a motive fluid, the working being impulsive. This method is most unsatisfactory for many reasons. The excessive temperatures involved inside the turbine casing would, as in the case of the reciprocating engine, necessitate water jackets. The great differences in pressure in the supply chamber, due to the explosive system of working, would effectively militate

against any economy in working, and would cause great irregularity of rotation, though this might be obviated by the use of a reducing valve. This would, however, itself be another cause of inefficiency.

A second method of working would be to have a turbine of the Parsons type, using as its motive fluid the products of combustion of liquid or gaseous fuel, burned under a constant high pressure in a separate chamber, the method of working approximating to that of a steam turbine. Here, however, it would be necessary on account of the high temperature, to reduce this before entering the turbine, either by cooling by water jackets, or by passing the gas thus formed through water, a mixture of steam and gas then going forward to the turbine.

The first of these methods suffers from the disadvantage that almost 50% of the heat is wasted initially, while the second has the disadvantage that, while no condenser is possible, the lower limit of temperature of working would be 212° F., instead of 40° or so with gas alone, unless the latter stages of the turbine were to be waterlogged. In addition the cycle is irreversible, and, thermodynamically, the whole process is very little better than that of the ordinary steam engine. The mechanical difficulties standing in the way of this method of working are considerable, and although many attempts have been made to overcome them, these have not met with any measure of success.

There is still another way of overcoming the difficulty. The gas may, as in the previous case, be produced at constant high pressure, and may be then led through diverging nozzles before passing into a turbine of the de Laval type. The gas is then expanded before entering the turbine, its pressure energy is turned into kinetic energy, and what in this case is most important, its temperature is so reduced by the expansion that on entering the turbine the temperature is within practicable working limit. The mechanical difficulties are not great, the chief being that of producing a constant supply of gas at a pressure of say 300 lbs. per sq. in. This, however, has been overcome. The machine would be light and of simple construction. Leakage in the turbine chamber would be immaterial producer gas or any liquid fuel could be used. There would be no loss of heat by water jackets, small radiation loss, and this only from the produce. Regulation would be easy, and the whole system compact. In fact, the advantages are so many and great, and the disadvantages so few, that it would appear highly probable that this type of prime mover will be the standard of the not distant future.

But the energy of chemical combination may be utilized in still another way, as in the case of an ordinary electromotive cell, to give electrical energy which may be directly utilizable for useful work. But for the cost of suitable materials, which makes this method prohibitive on any but a small scale, this would present very many and great advantages over the usual cycle of operations with its change of chemical energy to heat energy, heat energy to mechanical energy, and mechanical energy to electrical energy, and its corresponding losses at each transformation. Were it possible to use carbon as the positive electrode of a voltaic cell, the consumption of this carbon producing an electric current, a much greater proportion of its energy would be turned into useful energy, and many attempts have been made to solve the problem, with some small amount of success. The difficulties arise from the fact that while carbon in the form of coke is a good conductor of electricity, yet it is electro-negative to all but a few elements, and thus the choice of a suitable negative for the battery is limited. Also carbon is insoluble in all ordinary solutions. In spite of this, at least two methods of working, those of C. J. Reed and of Jacques, have overcome the difficulties, although in each of these cases a furnace with its accompanying consumption of fuel is necessary.

In view of the many difficulties to be overcome—of the low voltage available and of the cumbrous and costly construction necessary, it is highly improbable that any solution of the power problem will ever be found in this direction.

In conclusion, it would appear that for the present, at all events, and for such purposes as marine propulsion, where a highly concentrated supply of energy is essential, for some considerable time in the future, the energy latent in our coal and petroleum deposits will be that most widely drawn upon. As this supply becomes more and more exhausted, more use will have to be made of such sources of energy as are provided by our rivers and waterfalls, as a supplementary supply. Finally, as the cost of fuel becomes more prohibitive for power purposes, advantage will probably be taken, in suitable localities, of the energy of the tides, and also, in other suitable localities, of the radiant energy of the sun's

rays. As the second of these supplies is available with sufficient regularity only between latitudes about 40 degrees north and south of the equator, and as all heating for domestic purposes will then, on account of high fuel cost, probably have to be done by electrical means, there will, in all probability, in course of time, be a general moving of the industrial center of gravity of the earth's population to a point within these limits, where climatic conditions render artificial heat for domestic purposes to a greater extent unnecessary.

The prime mover of the future would appear to be in secular order, the steam turbine, the internal-combustion reciprocating engine, using producer-gas, and the internal-combustion turbine of the deLaval or Curtis type, the development of these going on side by side with that of the hydraulic turbine of the reaction or impulse type. Since the hydraulic turbine, to take advantage of tidal power, will have to work under variable and generally under low heads, the axial flow or Jonval type, on account of its general suitability for this method of working, will probably become more and more the standard type. Finally, as solar energy becomes more and more utilized, the steam turbine, certainly of the impulse type, will once again take the place of the now almost defunct internal-combustion engine or turbine. In every case the energy will in general be transformed and transferred or stored electrically until needed, and the success or otherwise of any future energy plant will, to a large extent, depend on the manner in which the transformation and transmission over long distances of high tension electricity becomes efficiently and easily possible.

For such purposes as marine propulsion and for aerial navigation, where a highly concentrated source of energy is required, putting aside the immense possibilities of radium or some such compound as a potential supply, it would appear that the internal-combustion turbine, having alcohol as its fuel, will finally become the standard motor.

The difficulties to be overcome before this is accomplished, are very small, the alcohol motor is a commercial success, and it only remains for the high cost to drive natural fuel from the field, for the alcohol motor to be used for this class of work.

One fact is certain, that in the future the engineer, using the term in its widest sense, will become increasingly more and more essential to the social progress of the universe, and that on his labors and inventiveness, more than on that of any other class of society, will depend the ultimate physical well being of mankind.

SCIENTIFIC WATERPROOFING

CONDENSED FROM "WATERPROOFING," FOR JULY.

The problem of how to protect structures from dampness is one whose solution was attempted in the remote ages of antiquity. The time-honored tradition of Noah's efforts to waterproof the ark with pitch is an evidence that the Patriarchs of old were no less averse to leaky habitations than are their more sophisticated descendants of to-day. Therefore, we have reason to believe that since the world was in its youth, there has been an unceasing struggle against the invasion of water into places designed for human habitation.

It remained, however, for recent years to witness the development of structural waterproofing from a mere makeshift to its proper place and station as a leading industry, controlled to a large extent by scientific principles, governed largely by scientific laws. The evolution was not accomplished without difficulty; there were many obstacles to encounter and prejudices to overcome, and waterproofing engineering may be considered the latest specialization of the engineering profession.

ADVANTAGES OF WATERPROOFING CONSTRUCTION.

Among the many advantages to be obtained from waterproofing structures may be mentioned:

1. An increase in the safety, life and healthy appearance of the building or structure.

2. The prevention of dampness, conducing to more wholesome conditions and greater comfort to the occupants.

3. The prevention of disfigurement to the exterior walls and interior decorations due to staining and efflorescence or other injurious action of water.

4. The dispensing with air spaces in buildings and with the necessity for furring and lathing, thus making possible, in many cases, a decrease in the actual cost. The elimination of air spaces in the walls removes what is a prolific breeding place for insects, creating an offensive condition, difficult to combat in even the best-kept houses.

WHERE WATERPROOFING MAY BE ADVANTAGEOUSLY EMPLOYED.

1. In the foundations of buildings extending below the ground-water level, to keep the basements free from ground water.

2. In building foundations not below ground level to prevent the absorption of ground-water and ground-air by the foundation walls, causing dampness in the building.

3. On exterior walls of buildings to afford some protection from the elements against defacement by efflorescence and against dampness.

4. On interior walls when used in conjunction with the exterior coat to dispense with furring and lathing, or in conjunction with the latter. Plaster may be applied directly to the inner waterproof coat, if the work is properly done and proper materials are used.

5. For buildings of a public character, and others which are designed to endure, the stone used, especially if not weatherproof in character or if susceptible to decaying influences, may be subjected to a protective process, and the mortar may likewise be treated, provided, however, that the strength and binding quality of the stone and mortar and the setting of the latter are not interfered with.

6. On structures which already show signs of decay, this decay may be partially arrested by a suitable waterproof application.

7. Concrete blocks and structures built of concrete, owing to their great affinity for water, should particularly be subjected to a waterproofing process.

8. In tunnels intended for public travel, water and dampness must be completely excluded. This becomes more difficult as the hydrostatic pressure is increased.

9. In structures intended to retain water such as reservoirs, standpipes, swimming pools, etc., the lining must be water-tight, or the structure will not fulfill its mission properly. Percolation into reservoirs and conduits from sewers or contaminated water sources must also be guarded against.

10. While the protection of structural metal from corrosion is, perhaps, a separate branch of the problem, the essential qualities of protective material for this purpose are quite the same as for those intended for masonry.

There are, unquestionably, other conditions under which waterproofing can be made a substantial aid in structural completeness, but these are sufficient to indicate the broad field open to the engineer and manufacturer.

ESSENTIAL PROPERTIES OF THE IDEAL WATERPROOFING MATERIAL.

1. The material should have no affinity for water. It should be a water shedder or "Contra hydra."

2. It should have a strong affinity for the material to which it is applied.

3. It should be non-porous and impermeable under all pressures.

4. It should be strong enough to bear pressure without breaking or cracking.

5. The bond between it and the protected material must be strong enough to resist any separating influences.

6. No water or gases should be able to find their way between the waterproofing and the masonry.

7. It should be elastic, so that it may expand and contract without suffering injury.

8. It should expand and contract at the same rate as the masonry, so as not to separate therefrom.

9. It should have a high melting and a low freezing point, so that it may be unaffected by extreme changes in temperature.

10. It should be a poor conductor of heat.

11. It should withstand settlement, shock, jar or vibration, and these should have no power to separate it from the masonry.

12. It should not be abraded by atmospheric dust, wind or water when used upon exposed surfaces.

13. It must be proof against chamical action due to atmospheric or to underground conditions.

14. It must be insoluble.

15. It must not decompose or disintegrate.

16. It must have no injurious effect on the strength or bonding quality of the stone or masonry to which it is applied.

17. It must not interfere with the setting of the mortar.

18. It should be uninjured by standing water, escaping gases, etc.

19. It should not discolor the surface to which it is applied when this is undesirable.

20. It should be cheap, easy to apply, and operative with unskilled labor.

A perfect material possessing all the essential qualities above mentioned cannot probably be found, but that which comes nearest to the ideal in the most important requirements should prove the best and most economical one to use under the particular conditions present in any given case.

PRECAUTIONS TO BE TAKEN FOR GOOD WORK.

There are a number of practical points which if kept in mind when conducting waterproofing work would avert many costly mistakes. Among the more important ones may be mentioned the following:

1. The structure should be designed so that it may properly receive waterproofing.

2. A head of water which has developed or is likely to develop, should be provided for by a well-arranged drainage system.

3. Only such materials should be used as are suited to the actual conditions. The success resulting from certain methods and materials used elsewhere is not always to be considered a criterion. Each individual case demands its special application, as to materials and methods.

4. The surfaces to be treated should first be freed from voids or irregularities that might interfere with the efficiency of the work.

5. Sufficient working room should be provided for the proper execution of the job. Cramping and crowding for space is not conducive to the execution of satisfactory work by a man wielding a long brush.

6. The waterproofing should be protected during and after the application. It frequently happens that waterproofing films are punctured through carelessness on the part of workmen or others, and the mischief thus done is only discovered after the structure is completed, when it can be repaired only at the cost of considerable money, besides loss of time, serious inconvenience and delays, and often friction and ill-feeling on the part of the various contractors.

7. The work should be continuous throughout and contain no weak spots. Water is an unfailing discoverer of such places.

8. The work should not be done in extremely cold weather. The limit may be considered as 20° F. Better results can be obtained by waterproofing when the weather is warm. The materials used in waterproofing are, necessarily, sensitive to chilly temperatures, and the properties which make for efficiency in this particular work are more or less affected by freezing weather. For instance, the application of hot bitumen-cement to an ice-cold wall will produce a sudden chill, and this goes far to destroy the cohesiveness of the felt layers.

9. Careful and conscientious, if not skilled, labor should be employed in waterproofing. Above all, the work should be always subjected to rigid inspection by a competent engineer, whose responsibility will be to see that those defects which can only be corrected at great expense later on shall be studiously averted.

10. In general, each waterproofing problem presents features peculiar to itself, depending on locality, service, climate and surroundings. Each problem must be studied and developed by itself, to secure the best and most enduring results. The supervision must be thorough, so that the designer's intention will not be thwarted by careless execution.

ELECTRONS AND THEIR PROPERTIES*

By SAMUEL SHELDON, Ph. D.

Electrons, which are called corpuscles by some physicists, are the smallest particles of matter that have been isolated. They are considered by some to be constituted of ether. Their shape is unknown, but it is frequently assumed as spherical. At ordinary velocities the mass of an electron is 6.3 10-28 grammes; at rest, its mass may be zero; and at velocities approaching closely to that of light it becomes nearly infinite. Each electron carries an invariable negative eletric charge of 1.1 10-19 [e] coulombs, 1.1 10-20 [= e_m] electro-

*From Presidential Address at the Niagara Falls Convention of the American Institute of Electrical Engineers.

magnetic units, = 3.4 10-10 [= e_s] electrostatic units. Some writers use the terms to designate as well particles carrying positive charges and having other properties. Such use is not common nor desirable.

Electrons in a free condition are present in metallic conductors, in gases, especially at low pressures, and to a limited degree in ordinary solid dielectrics. They are not present in free ether or space. Combined with other electrons and with an unknown something or condition that gives under certain conditions evidences of positive electrification, electrons are present in all matter. Their properties are in nowise dependent upon the properties of the matter with which they are associated, and they are considered to be indestructible by any agent within the command of man. Every electron is in some manner entangled with the luminiferous ether.

The ether is a fluid plenum or continuum, endowed with the properties of inertia and rotational elasticity, and is the medium through which all forces are exerted. It fills all space between electrons and the bounds of the universe; it is supposed by some to penetrate the electrons, and remains stagnant during the passage of electrons through it.

Each electron, when isolated and at rest, produces at every point in the ether an elementary electrostatic field, corresponding in direction and intensity to its charge. All electrostatic fields are due to the resultant superpositions of such elementary fields.

The Ion.—An important part is played in the phenomena of electrophysics by atomic aggregates of electrons that exhibit an external electrical field. When an aggregate or system of aggregates with an excess of positive or negative electrification is subjected to the influence of an auxiliary electric field it tends to move in the same or opposite direction to that of the lines of force of this auxiliary field, according to the sign of its excess of electrification. It may then be termed an ion, positive or negative, according to the sign of its excess of electrification.

Negative ions may or may not be associated with ordinary matter. Positive ions are always found associated with it.

Free electrons exist in gases at pressures under 10 millimeters of mercury, especially when subjected to ionizing agencies; in conducting solids; in the β rays from radium, and in conducting flames.

Clusters (in some cases roughly estimated as containing 30 molecules) exist in all conducting gases under pressures greater than 10 millimeters of mercury; sometimes in gases at lower pressures, and possibly in liquids and solids.

Electronized or de-electronized atoms, or both, exist in all conducting gases at all pressures; both exist in liquid electrolytes; in solid conductors, and possibly in solid dielectrics.

Metallic Conduction of Electricity.—Investigations concerning the nature of the process of electric conduction in metals have led to the conclusion that in the metals are to be found molecules and atoms of the metallic element, positive ions and free electrons. The molecules and atoms are not free to migrate from one part of the metal to another, but have a limited freedom of movement about a mean position. The electrons are not constrained to any particular part of the metal, but are free to move from one part to another, such movement being accompanied by collisions and changes in the direction of movement, in a manner similar to that accompanying the movement of molecules in a gas, considered from the standpoint of the kinetic theory of gases. The positive ions have been supposed by some to change their positions, by others not. The number of free electrons per cubic centimeter of metal is very large, being of the order of a billion billions. The mean free path of an electron scarcely exceeds one-millionth of a centimeter in any case. The number per cubic centimeter and the length of free path is different with different metals. In an ordinary metal at a uniform absolute temperature of T degrees all the particles of the metal are in motion, collisions are constantly occurring and the directions of the motion are such as result from chance. According to the doctrine of equipartition of energy the mean kinetic energies of the molecules of the atoms, of the positive ions and of the electrons are equal to each other and dependent upon the absolute temperature. Inasmuch as the masses of the electrons are much smaller than those of the other particles, the velocities of the electrons must be much greater.

Solid Dielectrics.—Solid dielectrics probably contain some free electrons, although the number per unit volume is small compared with that in metals. To free electrons is due the conductivity of solid insulators that remain after surface leakage has been prevented. Free atomic ions are probably absent, since conditions through their mediation would re-

sult in a transport of matter with accompanying differences in the chemical and physical character of the surface layers of the dielectric when kept between conductors having a maintained difference of potential.

Luminescence.—At all temperatures above absolute zero all bodies radiate energy. If the nature of the body be not changed by this radiation, that is, if it continues to radiate in the same manner, as long as its temperature is maintained constant by the addition of heat, the process is termed pure temperature radiation. If, on the other hand, the body changes because of the radiation and does not continue indefinitely to yield the same radiation, although its temperature is kept constant, the process is termed luminescence. The cause of some of the radiation in the latter case does not lie in the temperature of the system, but in some other source of energy. According as the extra supplied energy accompanies either chemical transformations, exposure to light, or the passage of electric currents, the processes are respectively termed chemico, photo and electro-luminescence. The total radiation from a body of this class is made up of two parts—that due to its temperature and that due to the extra energy. If the intensity of radiation of a body within any region of wave-lengths is greater than that of a black body at the same temperature, luminescence must be present. This is frequently taken as a criterion for the detection of luminescence. The frequencies of luminescent radiations are more or less restricted, being often evidenced by bright-line spectral distributions. The electrons which yield these radiations are supposed to vibrate harmonically under conditions that are not yet understood. That their movements are not governed simply by chance seems to follow from the character of the spectra. Although change in the character of the material as a consequence of its yielding luminescent radiation may not be capable of detection by chemical analysis, yet the atomic and molecular systems are nevertheless doubtless undergoing constant changes, due to the loss or gain of electrons. The entrance of an electron into a system, or its ejection, must, without doubt, occasion complex harmonic disturbances of many or all the electrons in the system.

If luminescent radiation be confined chiefly to wave-lengths of the visible spectrum the luminous efficiency of the body becomes high. Herein rests the economic significance of the efforts being made to advance the art of lighting by means of vacuum tube and flaming arc lamps.

A very interesting example of luminescent radiation is that which is yielded by photogenic bacteria, which are frequently found in sea-water and upon meats and fish that have been directly or indirectly infected by sea-water. They are the sources of light known as the phosphorescence of the sea. Some cases of phosphorescence in animals and in plants are explained as an infection with them. Gorham has shown that the light which they give is the result of chemical transformations accompanying metabolism inside the cells of their bodies. When fed with substances such as asparagin or glycocoll they are able to grow and reproduce but not to give light. In Gorham's summary occurs the following:

"We therefore conclude that for light production there must be present, over and above the requirements for growth, the oxygen of the air, sodium or magnesium, and certain organic acids derived from the decomposition of the carbon and nitrogen constituent of the food.

"The chemical energy resulting from the union of the sodium or magnesium with these organic acids, in the presence of oxygen, or from the latter combustion of the products of that union, is set free in the form of light."

The brightness of these bacteria considered as sources of light is very small. Lode's measurements show an intensity of emission of 0.00069 candle per square meter. This is too small to stimulate the color sense. The bacillus lucifer of Molisch, however, is much brighter, gives a continuous spectrum in the green, blue and violet, and is able to stimulate the color sense.

Conclusion.—Although much is known concerning the size and mass of the electron, its electric and magnetic effects when in motion, and its radiation effects during acceleration, little more is known concerning its structure than that it is the intrinsic strain-form alone that constitutes the electron; and it is a fundamental postulate that the form can move from one portion to another of the stagnant ether somewhat after the manner that a knot can slip along a cord.

THE ODOR OF METALS

FROM THE "MINING AND SCIENTIFIC PRESS."

Water chemically pure is a colorless, tasteless, odorless fluid; but in combination with other forms of matter it acquires each and all of these characteristics. Similarly it has been asserted by scientific authorities that metals free from alloys are odorless. In combination with other metals they frequently develop a strongly marked and sometimes a disagreeable smell, as in the case of copper alloys. Still the major premise was declared to hold until recently, when, according to report, as the result of exhaustive experiment, it has been established that all metals have their distinctive odors, which under set circumstances can be very perceptibly demonstrated. The proponent of the new theory is Herr Karl Gruhn, a Berlin metallurgical chemist and mineralogist, who has devoted much time and attention to the elucidation of his subject, and claims to have fully ascertained the origin and characteristics of the metallic odors. As a primary result of his experiments he asserts that even in its normal state each of the metals has its distinctive emanation, which is, however, so faintly perceptible as to have induced the assertion respecting its non-existence. This effluxion increases with the increase of temperature to a remarkable degree, and the rule applies equally to the royal as to the industrial metals. It is, however, most noticeable in connection with the latter, tin, copper, zinc, lead, and iron furnishing similar evidences of its application; and the odor is not at all affected by the oxidizing of the metal. Herr Gruhn found that each and all of the metals named when subjected to a high and sustained temperature gives out its odor in fullest strength after about an hour's treatment, but it then decreases, even when the temperature is still sustained, till the smell becomes as faint as before the temperature was raised. Then when the heat is withdrawn and the metal is allowed to cool, all trace of the odor disappears, as if it had been utterly driven off. An immediate return to high temperature re-develops the smell in only a faintly perceptible degree, but if a few hours are allowed to elapse before the metal is again heated it repeats in full strength all the phenomena attending the first test. It appears to have recovered from the exhaustion of its emanation and to have re-charged itself with the agents producing the odor. From these facts and the other data collected, Herr Gruhn arrives at a conclusion which challenges another commonly accepted belief. He disputes the theory that smells in their infinite variety are all produced by the effect upon the olfactory nerves of volatilized atoms from the effluxing substance which mix with the atmosphere, and so excite the sense. He says this is most decidedly not so in the case of metallic odors, which he affirms to be a property stored up by the substance and retained in a state almost quiescent till under the heat stimulus it is given off as are the radio-active properties of other minerals, and that as in the case of radium the emanations are unaccompanied by chemical change or loss of weight. The difference is that in the case of the odor there is an exhaust which is repaired by re-absorption, which in its turn is unaccompanied by chemical change or increase of weight. This relation to the radio-active properties of the uranian group and other allied minerals is indeed the asserted fact upon which Herr Gruhn lays chiefest stress, for he claims to have separated and isolated a metallic odor, and to have found that in its manifestations it establishes a strong affinity to the radio-active emanations of the rarer minerals.

THE LARGEST LOCOMOTIVE IN THE WORLD

MALLET ARTICULATED COMPOUND LOCOMOTIVE, 0-8-8-0 TYPE, ERIE RAILROAD

FROM "AMERICAN ENGINEER AND RAILROAD JOURNAL."*

All records of weight, size and power of locomotives have been broken by the completion at the Schenectady Works, of the American Locomotive Company, of the first of an order of three pushing locomotives for the Erie Railroad. These locomotives weigh 409,000 lbs., all of which comes on the eight pairs of drivers. They have a boiler measuring 84 in. outside diameter at the front end, containing 21-ft. tubes and a 4-ft. combustion chamber and a firebox with 100 sq. ft. of grate surface, in which soft coal will be burned. The tractive effort operating as a compound is 94,800 lbs. The locomotive and tender measure nearly 85 ft. in length, over all. It is nearly 15½ ft. in height and has a width of 11 ft. at the low pressure cylinders.

The first locomotive of this type to be built in this country was constructed a little over three years ago by the same company for the Baltimore & Ohio Railroad. At that time the design was looked upon with considerable suspicion by many railroad men. However, after being exhibited at the St. Louis Exposition the locomotive was put into pushing service on the mountains and within a comparatively short time proved to be a complete success in every respect. The present locomotive, while exceeding the Baltimore & Ohio engine by 65,000 lbs. in weight and nearly 24,000 lbs. in tractive effort, is of practically the same design in all of its essential details. Two other designs of the same type have been brought out in this country, both being for the Great Northern Railroad, one designed for pushing service and the other for regular road service. They were built by the Baldwin Locomotive Works. These engines, however, differ from the two designs just mentioned in having two-wheeled trucks, front and rear, making them of the 2-6-6-2 type. While they have been in service a comparatively short time the evidence is sufficient to show that they will be successful for the service intended. Hence, while the Erie engine is of a weight and size which a short time ago would have been considered practically impossible for a locomotive, it cannot really be looked upon as experimental, and all indications are favorable to its successful operation. They will be used in pushing service between Susquehanna and Gulf Summit, where the ruling grade is 1.3%. A tractive effort of nearly 95,000 lbs. should be capable of handling about 2,600 tons, exclusive of the locomotive, on this grade.

The term, Mallet compound, applies only to the arrangement of the cylinders and driving wheels with separate sets of frames connected through a hinged joint, and does not include any particular design of compound as concerns the distribution of steam. The Erie locomotives and also the one on the Baltimore & Ohio, are compounded on the Mellin system, which employs an automatic intercepting and reducing valve for admitting live steam at a reduced pressure to the low pressure cylinders in starting, and for increasing the pressure in those cylinders at any other desired time. The locomotives on the Great Northern Railway are designed with a plain system of cross-compounding without intercepting valves or other automatic arrangements, having, however, a small pipe connection from the boiler to the receiver pipe, by means of which live steam can be admitted at the discretion of the engineer.

In spite of the fact that this locomotive weighs 409,000 lbs. it has a weight per driving axle which is less than many large freight locomotives now in service and less than any previous Mallet compound locomotive, except the ones for road service on the Great Northern Railway. One of the features of greatest advantage of the Mallet type is that an enormous amount of power can be centered in one

* We are indebted to the courtesy of this journal for the use of the original illustrations.

machine which will be capable of operating over the same track that other heavy freight locomotives use.

The boiler is of the radial stay type with conical connection sheet, the inside diameter of the first ring being 82 in. and that of the largest course being 96 in. The heaviest ring of the shell is 1 3-16 in. thick. A steam pressure of 215 lbs. is carried. The tubes, of which there are 404, are 21 ft. long and are 2¼ in. in diameter. This length of tube, taken in connection with the 4-ft. combustion chamber, places the front tube sheet 25 ft. from the firebox, a figure which has never before been equaled in locomotive service. The combustion chamber itself is radially stayed from the shell of the boiler, and is provided with ample water space on all sides. The mud ring is 5 in. in width at all points, and the crown sheet has a slope of 5 in. from its connection to the combustion chamber to the door sheet. The dome is placed about central in the length of the boiler, since the locomotive is to operate in either direction and on heavy grades.

A novel design of throttle valve has been fitted to these locomotives, which in addition to taking steam at the top only, also acts as a steam separator. The arrangement is such that the entering steam strikes against the curved surface of the upper bell upon which the entrained water will be deposited, and following the surface of this casting will pass down through the center of the valve to an outlet below. The top of the bell casting does not take a bearing, and hence it does not in any way act as a valve. The steam is led from the throttle pipe through a short dry pipe to a point directly above the high pressure cylinder, where it passes through the shell to a T-head on top of the boiler and thence through wrought-iron steam pipes on either side to the top of the high pressure steam chest.

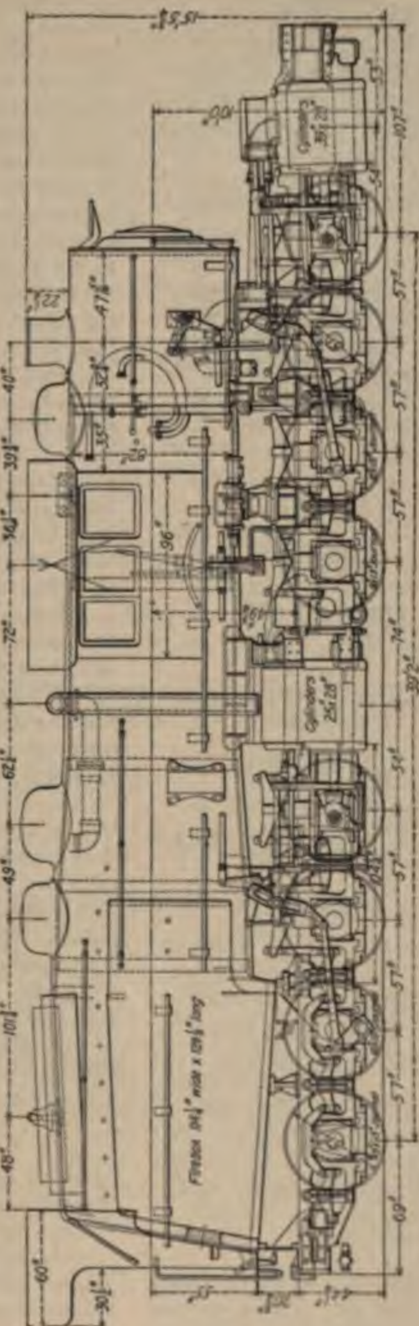
Owing to the extreme width of the firebox it was necessary to place the cab over the boiler shell near the front, and hence all the controlling apparatus, injectors, etc., are located on the right-hand side. The injectors feed through a double check valve located on the center line of the boiler, but a short distance back of the front tube sheet.

The high pressure cylinders are cast in pairs with saddles, the separation between the two cylinders, however, being 8½ in. to the right of the center. This permits the intercepting valve to be placed in the left-hand cylinder casting and also gives room for the connection to the receiver pipe. The exhaust steam from the right cylinder continues from the passage in its saddle to an outside U-shaped pipe connecting to a passage in the left-hand cylinder casting which leads up to the intercepting valve chamber into which the exhaust steam from the left cylinder also passes. From this point the exhaust steam passes to a 9-in. receiver pipe extending forward between the frames to the low pressure cylinders. An extra exhaust connection is provided in the side of the left cylinder casting, which has a 4½-in. pipe leading to the exhaust pipe in the smokebox. This connection is made by a pipe having universal joints in a manner similar to the receiver pipe. The construction of the receiver pipe is such as to permit free movement of the front frames in all directions, it being fitted with a ball joint at either end and a slip joint near the forward end. It is arranged to permit the locomotive to pass around 16-degree curves. The low pressure cylinders are cast in pairs, the connection to the receiver pipe being made through a Y-shaped casting connecting at the back to the cored passages in the cylinder. The exhaust is carried through an elbow located on top, and in the center, to a short pipe with universal joints leading to the exhaust pipe in the front end.

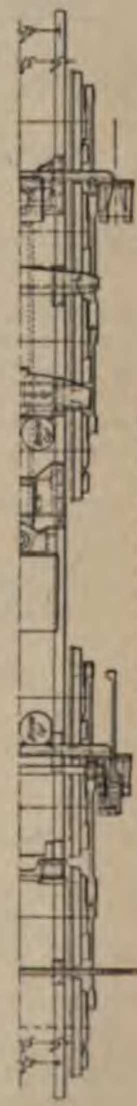
The high-pressure cylinders are fitted with piston valves having internal admission while the low-pressure cylinders have balanced slide valves with external admission. The valve gear, which is of the Walschaert type, is so arranged that the return crank leads the pin in both sets, and hence the block is at the bottom of the link for the go-ahead motion for the low pressure cylinders and at the top of the link for the high pressure cylinders. In this way the weights of the two valve gears counterbalance each other. The operation of reversing is further assisted by a pneumatic reversing device, which is connected to the reverse lever and consists of two cylinders, one of which contains oil under pressure for locking the device in any desired position, the other cylinder being the air cylinder. The operation of this device is controlled from an auxiliary reversing lever in the cab.

In the construction of the cast-steel frames special care has been given to obtaining a thorough system of cross bracing. The articulated connection between the two groups is made in practically the same manner as was used on the Baltimore & Ohio locomotive, the hinge joint being formed in castings secured

THE LARGEST LOCOMOTIVE IN THE WORLD.



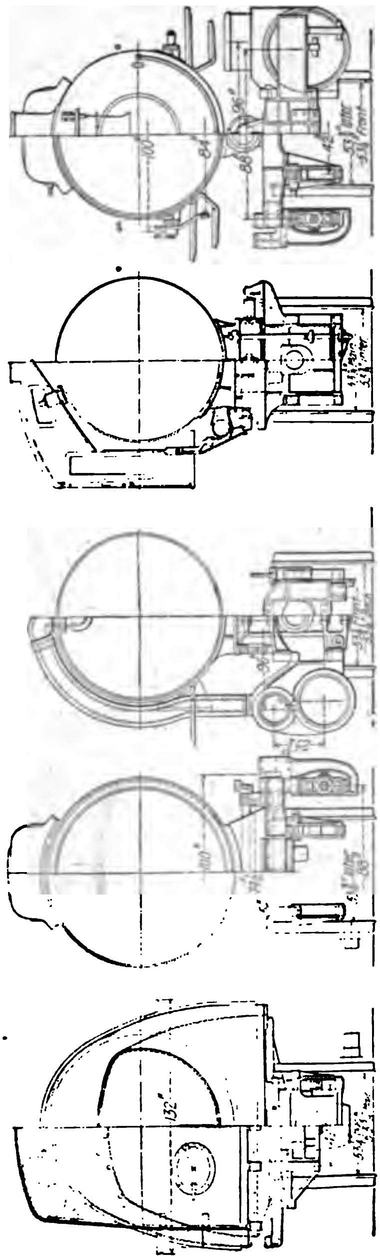
SIDE ELEVATION.



HALF PLAN OF RUNNING GEAR.

of the high pressure cylinder. The verti- ... is connecting the upper rail of the front ... with the lower rail of the rear group ... ed with ball joints to permit free move- ... f the two frames relative to each other, ... re provided for holding the frames in line and preventing binding on the hinged connection.

The weight of the boiler extending beyond the high pressure cylinder saddle is transferred to the front set of frames at two points, which are normally in contact, and two other



CROSS-SECTIONS OF ERIE MALLET COMPOUND LOCOMOTIVE.

points, which will come into contact under unusual conditions. The one which carries the largest amount of weight has a self-adjusting sliding bearing, and is located between the third and fourth pair of drivers. This bearing will permit free movement in all directions in the horizontal plane, and also includes a safety connection which prevents the frames from dropping away from the boiler in case of any derailment. There is also a similar safety connection provided at the front end of the boiler between the guide yoke casting and the exhaust pipe elbow. The other support between the boiler and frames is located between the second and third pair of drivers and consists of two vertical columns located just inside the frames and fitted with ball joints at either end. The upper end takes a seat in projections on the casting fastened to the boiler and the lower end seats in castings having one end hinged below a frame cross tie across the lower rails. These hinged castings are held in place by U-bolts at the opposite end, which pass up through the cross tie and are supported on coiled springs. In this manner a flexible connection is formed by the use of comparatively light springs and this support will take a varying load corresponding to the location of the frames with reference to the boiler. The initial compression of these springs is 30,000 lbs., and can be varied as found desirable.

A spring centering device is located between the second and third pair of drivers just ahead of the column support mentioned, and is provided with coiled springs for bringing the front group into line after leaving a curve. This construction also includes an emergency bearing which is normally separated about ½ in.

The front group of driving wheels are equalized together on each side and cross equalized in front of the forward drivers, thus making this system equivalent to a single supporting point. Each side of the rear engine is equalized independently. The locomotive is fitted with two New York duplex No. 5 air pumps and carries four air reservoirs located on top of the firebox and arranged as shown in the illustration. The general dimensions, weights and ratios are as follows:

GENERAL DATA.

Tractive effort, compound	94,800 lbs.
Weight on drivers	409,000 lbs.
Weight of engine and tender in working order	572,000 lbs.
Wheel base, driving (total)	39 ft. 2 in.
Wheel base, engine and tender	70 ft. 5½ in.

RATIOS.

Weight on drivers ÷ tractive effort	4.32
Total weight ÷ tractive effort	4.32
Tractive effort × diam. drivers ÷ heating surface	910.00
Total heating surface ÷ grate area	53.14

Firebox heating surface ÷ total heating surface, per cent 6.46
Weight on drivers ÷ total heating surface 76.90
Volume both cylinders, cu. ft. 24.00
Total heating surface ÷ vol. cylinders 222.00
Grate area ÷ vol. cylinders 4.17

CYLINDERS.

Kind .... Mellin compound
Number 4
Diameter .... 25 and 39 in.
Stroke .... 28 in.

WHEELS.

Driving, diameter over tires .... 51 in.
Driving, thickness of tires .... 3½ in.
Driving journals, main, diameter and length .... 10 × 13 in.
Driving journals, others, diameter and length .... 9 × 13 in.

BOILER.

Style .... Straight, with Conical Connection
Working pressure .... 215 lbs.
Outside diameter of first ring .... 84 in.
Firebox, length and width .... 126⅛ × 114¼ in.
Firebox, plates, thickness .... ¾ and ½ in.
Firebox, water space .... 5 in.
Tubes, number and outside diameter .... 401 — 2¼ in.
Tubes, length .... 21 ft.
Heating surface, tubes .... 4,971.5 sq. ft.
Heating surface, firebox .... 343.2 sq. ft.
Heating surface, total .... 5,313.7 sq. ft.
Grate area .... 100 sq. ft.
Smokestack, diameter .... 18 in.
Smokestack, height above rail .... 15 ft. 5¾ in.
Center of boiler above rail .... 120 in.

TENDER.

Tank .... Water Bottom
Frame .... 12-in. 40-lb. Channels.
Wheels, diameter .... 33 in.
Journals, diameter and length .... 5½ × 10 in.
Water capacity .... 8,500 gals.
Coal capacity .... 16 tons

THE CHARACTERISTICS OF GOOD BUILDING STONES

By R. D. GEORGE

FROM THE "JOURNAL OF ENGINEERING," UNIVERSITY OF COLORADO.

Of all building materials, stone is best suited to the main structural features of large buildings and great public works, because it alone has the qualities of strength, durability and dignity of appearance so generally sought in the erection of such structures. But many varieties of building stone are well adapted to the building of residences. And, for the laying of foundations, whether for buildings or for bridges and other public works, stones will probably continue for some time to hold first place among building materials.

The essential qualities of building stones are: 1. Strength; 2. Durability; 3. Workability; 4. Color and beauty.

1. STRENGTH.

The strength of a stone is measured by its ability to withstand stresses. A stone in a wall is subjected to strains of various kinds. Of these, the most important are the crushing, the tensile, the transverse and the shearing stresses.

Factors determining the strength of a stone and the permanence of its strength are composition, texture, structure and mode of aggregation.

Composition.—The different minerals of which building stones may be composed vary widely in hardness and resistance to crushing force. For example, quartz is harder and has a higher crushing strength than calcite or feldspar. It is harder, but has a lower crushing strength than hornblende. Again, different minerals have different coefficients of expansion under changes of temperature; and the stresses resulting from differential expansion and contraction are more important in a rock composed of several minerals than in a rock composed of only one. Some minerals, such as calcite and feldspar, have a very pronounced cleavage;

while others, like quartz, have little or none. Cleavage renders a mineral weaker in certain directions than in others.

The solubility of the materials of a rock is an important factor in the permanency of its strength. This is particularly true in the matter of the cementing material in sandstones and other clastic rocks, where the weakening or removal of the bond between the grains would leave a crumbling mass.

Texture.—Other things being equal, coarse textured rocks are weaker than fine textured rocks of the same composition. There is less interlocking of the component grains, more unoccupied space, and the contact planes between the minerals are distributed in fewer directions.

Structure.—The structural feature of most importance in building stone is lamination. Stones are stronger and weather better when laid with their lamination planes in a horizontal position.

The crushing stress to which a stone would be subjected in the basal tier of a very high wall is far within the initial crushing strength of any stone which would be considered fit for building purposes. Almost any stone that will stand quarrying and shipment will have a crushing strength high enough for perfect safety in all ordinary structures. Builders will rarely place a stone where the direct pressure upon it will exceed one-tenth of its crushing strength.

Stones in a wall are rarely subjected to direct tensile stress, but their ability to withstand transverse and shearing stresses depends largely upon their tensile strength.

Transverse stress is stress applied at right angles to the length of the block. The cracking of stone and brick walls is usually due to transverse stress resulting from unequal support throughout their length. In the cracking and separating of the two parts of a wall there is usually a component of tensile stress, but it is seldom great.

Transverse stress generally results from the settling of foundations or from the failure of the builder to give the stone uniform support from end to end. As shearing is a change in the form of a mass without change of volume, it is evident that the [illegible] is an index of the [illegible] change of form [illegible] sion of the component [illegible] overcome, or in other words, until the tensile strength is exceeded.

2. DURABILITY.

The durability of a stone depends chiefly upon its ability to withstand the climatic conditions to which it is exposed. The principal agencies of disintegration and decay may be divided into two classes:

(a) Mechanical, including: Temperature changes, water, wind, mechanical wear in the place where it is used.

(b) Chemical, including: Water, atmospheric gases, organic acids, etc.

Temperature Changes.—Change of volume in response to change of temperature is one of the most important causes of rock disintegration. It is more effective in crystalline rocks than in non-crystalline rocks of the same composition. The coarser the texture, the greater the strain. Rocks composed of several different minerals suffer more than those containing only one. A granite may contain quartz, feldspar and hornblende. The coefficients of expansion of these minerals are proportional to 36, 17 and 28, and as a result unequal stresses will be set up within the rock whenever expansion or contraction takes place in response to change of temperature. In a rock composed of but one mineral there is but one coefficient of cubical expansion, and the strain is more uniform. The coarser the grain of the rock, the greater the liability to disruption.

The coefficient of lineal expansion of a mineral grain is different in the direction of the different crystal axes. These unequal expansions create similarly unequal stresses in the different directions.

A porous rock will probably suffer less from this force than will a compact one of the same composition, owing to the fact that a part of the expansion will be accommodated by the intergranular spaces. On the other hand the area of intergranular contact is less in the porous rock and consequently the work to be accomplished in separating the grains is less.

Stone is a poor conductor of heat, and under the influence of a midday sun the outer surface may be brought to a high temperature before the opposite side of the block has felt the effect of the sun. This causes a differential expansion which tends to weaken the [illegible] not getting the direct [illegible] heats up more slowly and [illegible] the resulting differential [illegible] less. In winter the inside surface of a wall may have a temperature of 70°

F., while the outside may be at 30°. In large fires, stone walls may become intensely heated. If water is turned on the hot stone, it splits in layers parallel to the outer surface. Under such conditions granite probably suffers most and sandstone least of the common building stones. Limestones, dolomitic limestones and marbles suffer comparatively little up to a temperature of 900° to 1,000° F., providing they are not suddenly cooled. Above this temperature they are likely to be changed to quicklime, and slacked when exposed to moisture. The behavior of sandstones under similar tests is usually good, though sudden cooling with water seems to cause a greater degree of disintegration than in the case of limestones.

Water.—As an abrading agent, water has very little effect upon the stones in the walls of buildings. But water within the stone may be the most powerful agent of mechanical disintegration to which building stone is exposed. This water, apart from changes of temperature involving freezing, is quite unimportant as an agent of mechanical disintegration. But in freezing, water expands about 9%—100 volumes of water forming 109 volumes of ice. The force of this expansion is equal to a pressure of about one ton per square inch, and as it acts between the grains of the rock, its effect is to break the bonds holding them together and so cause crumbling. It is a severe test of the tensile strength of a rock.

But the destructive effects of freezing are not proportional to the amount of water a stone can absorb and retain. Much depends upon the character of the pores or openings containing the water, and upon the degree of saturation of the stone at the time of freezing. While rocks with very small pores retain the absorbed water longer, they take it up much more slowly and are less likely to become saturated with storm waters than are those with larger pores. All things considered, it is well to avoid stones having a high absorption ratio, and especially if they are of fine texture.

Certain rocks contain measurable quantities of readily soluble salts. In others, such salts are formed by chemical reactions between some of the constituents of the stone and those of the atmosphere. Under ordinary atmospheric conditions these salts are crystallized, dissolved, and recrystallized within the stone, and the mechanical strain accompanying the process loosens and separates the grains of the rock. This is a very important consideration in connection with the laying of foundations in alkali-rich soil. The ground water carries the salts into the stone and, when the water evaporates, they crystallize with expansion, developing a force similar to that exerted by water in freezing.

Many minerals, when exposed to the action of water, become more or less hydrated. As a rule, this change involves change of volume, and as each mineral has its own ratio of expansion from hydration, and as some minerals are more likely to become hydrated than others, it is plain that the process of hydration will cause unequal stresses. The mechanical effect is similar to that of expansion from rise of temperature, but there is not the alternate expansion and contraction which accompanies temperature changes. The upper walls of a building are not likely to suffer appreciably from hydration, but the stones of the foundation may be saturated for long periods of time, and, as a result, become partially hydrated.

Mechanical Wear in Doors, Steps, etc.—Of the commoner building stones, granite and quartzite are most resistant. The wearing qualities of sandstones will depend upon the cement between the grains and the strength of the bond it affords. Those having a siliceous cement are most durable, especially if the cementing silica is united with the grains by crystal growth. Limestones are, as a rule, unsatisfactory floor and step stones, owing to their softness.

Chemical Agencies.—The principal agencies of chemical disintegration are: 1. The normal constituents of the atmosphere—nitrogen, oxygen, carbon dioxide and water vapor. 2. The impurities, or accidental constituents—ammonia, nitric, sulphurous and sulphuric acids. 3. The compounds formed by reactions between members of groups one and two, and the constituents of the stone. 4. Organic compounds derived chiefly from plant life.

Of the first group, oxygen, water and carbon dioxide are important. For convenience their work is frequently referred to under the headings: Oxidation, hydration and solution, carbonation. But it is not likely that any one of these processes would be important without one or more of the others, and it may be doubted whether, under natural conditions, any one of these goes on separately. The chemical breakdown of a rock is a very complex process, involving many reactions and interactions.

It is, perhaps, as a medium through which other chemical reagents may work, that water plays its most important part in the chemical breakdown of rocks. From the air it gathers oxygen, carbon dioxide, sulphuric and nitric acids. From the soil and disintegrating rocks it derives organic acids and mineral salts. All these are carried by it to the rocks with which it comes in contact. But this is, in part, mechanical, and in part chemical. Solution and hydration are other important phases of the work of water.

As a solvent, pure water has very little effect upon rock-making minerals, but the waters which come in contact with building stones are rarely pure. They have become dilute acids, and their solvent power is greatly increased.

Limestones and marbles, sandstones with ferruginous and calcareous cement, the feldspars and ferromagnesian minerals of granites and other igneous rocks are most readily attacked. Ordinary pure, compact, non-granular limestones are not so seriously affected. The texture prevents the acidulated waters from penetrating far into the stone before evaporation checks its course. But the porous, crystalline granular limestones and sandstones offer more favorable conditions for the work of solution. The water penetrates the intergranular spaces, dissolves or weakens the bond between the grains, and prepares the way for crumbling.

Under ordinary conditions carbon dioxide is probably the most important aid water has in its work of solution. This is due to its universal presence, and to its very general, though slow, solvent action upon the rock-making minerals.

As a rule, the dark minerals (hornblende, biotite and pyroxene) of the granite break down before the feldspars and quartz. In this process many secondary minerals are formed and may completely fill the space once occupied by the dark minerals. Under certain conditions the new minerals formed require more space than the original and so mechanical strain results from their formation. But in most cases a part of the constituents will be removed in solution. No matter what the process may be, the result is generally the weakening of the stone.

Hydration apart from oxidation and solution, is probably of little importance except where long-continued saturation occurs. So far as building stones are concerned only those used in foundations are likely to suffer. Even here, the mechanical effects of hydration are more important than the chemical.

Sulphuric, sulphurous and nitric acids are present in appreciable amounts only in the atmosphere of large cities where the consumption of coal is large. Careful tests made on scrapings from the partially disintegrated surface of the Bedford (Ind.) limestone in the older buildings of the University of Chicago, which have stood for ten or eleven years, show 2.33% of sulphuric anhydride—an amount almost incredibly large. Making allowance for loss by solution in the process of change, it is evident that approximately 3% of the surface of the original limestone has been converted into gypsum.

Sixteen analyses of the Bedford stone show no trace of sulphur. A microscopic examination showed that considerable intergranular matter had been carried away by solution, but it was impossible to determine satisfactorily the effective agency.

Solution is also aided by organic acids developed in the decay of plant material. Chemically, the formation of soluble salts, such as magnesium and calcium sulphates from the reaction of sulphuric acid on magnesium and calcium carbonates, has but little effect, and the mechanical work has been discussed. The oxidation of iron pyrite may result in the formation of sulphuric acid and cause local chemical action of an injurious character.

3. WORKABILITY.

Stones suitable for building purposes differ widely in the ease with which they may be quarried and prepared for architectural use. Under workability must be included quarrying, dressing and decorative working. In quarrying, the larger structural features of the rock mass are of great importance. It is desirable that the beds should be well defined and of such thickness that all the stone may be marketable without an undue amount of labor. The horizontal position of bedding greatly facilitates the handling of the quarry product and makes the use of quarrying machinery more possible. Distinct and regular spacing in at least one direction, is a boon to the quarryman in that the split surfaces of much of the quarry product need no further dressing.

In igneous rocks, the absence of true bedding [illegible] of even greater [illegible] sedimentary rocks, and [illegible] well-defined joints in an approximately horizontal position, much

ive undercutting or "gadding" is neces-

sing is at best a slow and expensive s, and many otherwise desirable stones be placed on the market because of the lty of dressing them. Many stones take isel with almost equal facility in all di- s, while others have such pronounced g or grain, or both, that satisfactory g is very difficult. Fine decorative on such rocks is almost impossible. certain stones readily take a beautiful sting polish, while others are difficultly ed and incapable of retaining a good e. Easy quarrying, easy working and lity make a desirable combination in g stone.

4. COLOR.

tone and permanence of color are of erable importance in building stones, ally in large cities where fashion rather utility may be the determining factor in oice of building material. It is a rare to find absolute uniformity of color in rry. The common coloring matters of entary rocks are carbonaceous material and salts of iron. Carbonaceous matter usually gives brown and black tones, while the iron salts give blues, grays, buffs, browns and reds—the shade depending largely upon the state of oxidation of the iron present. If the iron is present as a sulphide, weathering is likely to cause oxidation and a darkening of the color toward buff, brown and red. If it is in the protoxide form, the color is likely to be gray, blue-gray and blue. Further oxidation may produce about the same tones of buff, red and brown as those from the iron sulphide. A rock colored brown or red by hematite is likely to keep its color, though in time some of the iron may be washed out and leave the stone of a lighter shade.

The color of igneous building stones depends largely upon the important mineral constituents, rather than upon coloring matter proper. For this reason the color is more likely to be permanent. But if the percentage of the ferromagnesian minerals is large, weathering may result in a complete change of tone or intensity of the color, owing to the partial breaking up of these minerals and the separation of iron salts, and a change in their state of oxidation.

MODERN METHODS OF SEWAGE PURIFICATION

By A. ELLIOTT KIMBERLY

FROM A PAPER READ BEFORE THE OHIO ENGINEERING SOCIETY

adequate protection of inland streams kes from pollution by the sewage of cit- d towns has become one of the great ms of the present day. From the early es the advance in knowledge of the art age purification has been so great that as a result of research and of exper- gained by the operation of sewage puri- n plants upon a large scale, it is gen- considered practicable to carry the puri- n of domestic sewage to such a state the once foul liquid is rendered stable o longer shows putrefactive tendencies.

blem of Sewage Purification.—Shortly the introduction of the water carriage system of sewerage in 1855, it began to be recognized that the withdrawal of the liquid wastes of the community from the immediate neighborhood of the city or town did not entirely effect their satisfactory disposal, especially where such communities were located on the banks of streams of small flow subject to summer drought. During such low flows, offensive odors would emanate from the sludge deposits on the drying shores, affecting the health and welfare of the inhabitants of the community itself or of others located below upon the same stream. For the benefit of the community itself, or as a result of suits on the part of the lower riparian owners, it

became necessary to adopt such means for the purification of the polluting discharges that the original purity of the stream would be restored to as great an extent as practicable. Such, in a general way, is the case today, especially in inland cities and towns located upon the banks of small streams. A dilution of from 36 to 45 to 1, such as is usually considered to be sufficient to prevent putrefaction on the part of mixed sewage and river water, is usually obtainable only in the case of cities or towns situated on the shores of the larger rivers, hence in other cases the problem of the purification of sewage presents itself for consideration.

As it is well known, the extent to which it is necessary to carry the purification of domestic sewage is governed largely by local conditions. By this is meant that according to circumstances of flow of a stream, the character of its waters and their subsequent use as a source of water supply, the needed degree of purification of the sewage discharged into the stream may vary within wide limits. Aside from the discharge of sewage into the sea, where after rough screening, putrefaction is overcome by processes of dilution, the needed degree of purification of domestic sewage may be said to be governed by three general rules. These are as follows.

1. Where the sewage effluent is to be discharged into running streams subject to floods and with a water containing considerable turbidity at all seasons of the year, the degree of purity required need not be more than that of an effluent which undiluted will no longer putrefy under conditions met with during the summer season.

2. In streams the waters of which are clear except at times of flood, the purification of the sewage should be such as to remove from it the largest practicable quantity of suspended matter so that the visible [illegible] of the stream will not be affected, the non-putrefaction of the effluent being taken as coincident with a degree of [illegible] which will afford an absence of [illegible] amounts of turbidity.

3. In drinking water streams [illegible] certain cases of sea discharge [illegible] layings must be protected [illegible] tion the [illegible] needs be carried [illegible] besides the [illegible] chemical [illegible] effluent [illegible] reduces itself to the least [illegible] the disease-producing bacteria present in the raw sewage, by subjecting the well-purified effluent to some form of sterilization process.

The conditions referred to in the first instance are such as obtain quite generally in Ohio and the Middle West. In practically all of the plants in operation in this State, the attainment at all times of a non-putrescible effluent would satisfactorily accomplish the purpose for which the sewage plant was installed. That is to say, in this section of the country where the glacial drift formation is absent and where abound clayey soils subject to easy erosion, practically all streams are muddy throughout the year, and except in a few cases where there is involved the protection of a water supply, the abatement of a nuisance from the discharge of sewage into small streams with but low dilution, is readily effected by processes of purification, depending upon the use of filters of coarse material operated at fairly high rates and yielding effluents, which, when clarified by subsidiary subsidence, mixed with river water, successfully pass tests of ultimate stability.

In cases where streams are of low turbidity except in flood stages, processes of sewage purification looking merely to the ultimate stability of the effluents therefrom, owing to the suspended matters incidental to their effluents, will tend to impair the general appearance of the stream, and in these, advantage must be taken of types of purification processes involving the use of materials of fine grain and operated at comparatively low rates. Such conditions are generally found in New England and in some of the States upon the Atlantic coast line, where, fortunately sandy areas of suitable size and character are usually available, and under proper supervision and intelligent management, the use of these areas produces effluents of a high degree of purity containing but small amounts of suspended matters for the greater part of the year.

In streams used subsequently as a source of water supply the discharge of sewage [illegible] must be prevented whenever possible. [illegible] are to be found, however, of [illegible] under such conditions as the [illegible] there becomes necessary a [illegible] sewage treatment that not only will [illegible] be called the chemical [illegible] but such as will de[illegible] pathogenic origin as well. [illegible] practical knowledge has [illegible] this country as to the prac[illegible] the bacteria of disease

which the most thorough practical sewage treatment fails to remove. Considerable recent work, however, has been done along this this line in England and in the United States, and experiments have been conducted in several places in this country looking to a solution of this phase of the sewage problem. A number of disinfectants have been tried thus far, chief of which may be mentioned: Lime, acids, ozone, permanganate, chlorine as bleaching powder and also produced electrolytically, and copper sulphate.

Data are yet too meagre to enable conclusions to be drawn as to the practicability of the disinfection of sewage effluents, in part as to the most efficient reagent to be employed, and in part on the grounds of cost, but with accumulation of evidence from experiments carried out up to the present time, it appears to be quite generally recognized that the day is not far distant when drinking-water streams will be rendered free from pollution by sewage bacteria of disease origin by the use of sterilizing agents, before the sewage effluent carried to a non-putrescible state by a modern process of sewage purification, shall be allowed admission into a stream used below the outfall for domestic consumption.

The older chemical precipitation processes at best effect a clarification of the sewage with a removal of from 50 to 60 per cent. of the suspended matters, but, of course, the resulting effluents are highly putrefactive, of foul odor and require a high dilution with river water to prevent the rise of a nuisance along the shores of the streams into which they are discharged. In some instances, moreover, the effluent appears to be more highly putrescent after chemical treatment than before, due, it would appear, to the well-known solutionizing action of lime in excess upon suspended organic matters.

In general, it may be said that the treatment of sewage by chemical precipitation alone will probably be productive of foul odors and obnoxious conditions, in addition to the heavy burden of sludge disposal, and in the speaker's opinion, the process, except in rare cases, is to be considered superseded by those of more recent origin.

In the smaller plants, sewage is treated either upon areas of sandy soil, at times also heavy with clay, or upon sand filters of artificial construction, according to the well-known process of intermittent filtration. The variation in the details of a sewage plant of this type is very great, especially as to the character of the filtering medium, the method of flooding the filters, the amount of sewage applied at each dosing, and the amount of preparatory treatment to which the applied sewage has been subjected.

Excellent results are being obtained by the intermittent filtration process in cases where the material is of suitable grade, the quantity of sewage to be treated is not excessive, and where the supervision is such that the filters receive the proper amount of attention, by which is meant the raking of the surface material, the operation of the filters upon a strictly intermittent basis, in the absence of automatic flooding devices, and the thorough cleaning of the filters in case there develops evidence of ponding due to over-dosing or to clogging on the part of the surface layers.

In a number of plants constructed in the last eight years, some form of preparatory treatment has been included in the design aside from the older chemical precipitation processes. Chief of these processes is the treatment of the crude sewage by sedimentation in septic tanks, wherein there is effected a removal of about 50 per cent. of the suspended matter of the crude sewage with the resulting liquefaction of from 25 to 50 per cent. of the deposited sludge. At the present time there are 15 septic tanks in operation in this state; of this number 12 are covered and three are open tanks.

The general appearance of the different septic tanks varies greatly. Of those mentioned above, some appear to destroy sludge readily, while in others the accumulation of sludge is quite rapid. The presence or absence of scum on a septic tank is somewhat difficult to foretell, as it seems to be dependent upon several conditions, chief of which perhaps is the relative strength of the sewage, dependent on the per capita sewage flow. With a small per capita flow, sewage tends to possess a turbid, milky appearance, is strong smelling after but short storage and contains a relatively large proportion of colloidal suspended matters. highly diluted sewage, especially where large amounts of surface water are included, generally carries suspended matters of a flocculent character, capable of rapid subsidence under a reduced velocity and at times carries a small amount of dissolved oxygen through the septic tank. Broadly speaking, sewages may be separated into the above two classes, the division between which is rather indefinite. From the observation and the experience of

the speaker, however, it has been noted in many instances that scum formation and highly concentrated sewage are in some way intimately related, as in the case of tanks treating weak sewages, the rising sludge forced upward by the gases incidental to sludge fermentation generally falls back again before a permanent scum has an opportunity to be formed.

The efficiency of the septic tank may now be said to be dependent upon the relative quantity of suspended matters that may be removed by the tank, the older view of the modification of the liquid portion of the sewage itself having been disproved by a number of instances in recent years. Without the aid of chemical analysis and carefully averaged samples extending over a considerable period, it is of course difficult to judge of the actual efficiency of the septic tank. At the same time, from the general appearance of the oxidizing devices and from the fact of the successful operation of the plant at rates considerably higher than would be possible were the raw sewage applied to the filters, it will be apparent that the septic tank as a preparatory process for the removal of a part of the suspended matters in many instances has proven itself an important factor in sewage purification.

There is another side of the treatment of sewage in septic tanks that deserves considerable attention, namely, the disposal of the residue from the hydrolysis of the sludge. The first advocates of the septic process were firm in their convictions that at last there had been devised a process for sewage treatment that would effectually solve the problem of the sewage problem, the disposal of the sludge. Many statements were made and many views were expressed that a septic tank, when installed, would never require cleaning: that in some manner not clearly understood it was capable of destroying the sewage solids to be subsequently applied to it. Such views are now known to be untenable. While the process does effect the destruction of a certain proportion of the deposited suspended matters, yet there always remains an ever-accumulating quantity of sludge which in course of time requires removal, in fact in the most modern designs sludge areas are provided for the cleaning of the tanks.

In addition to the above mentioned points in regard to the efficiency of septic tanks, there is still another phase of this form of preparatory treatment which deserves more than a passing notice, that is, the periodic upheaval of the sludge deposits and the consequent clogging of the oxidizing units by the suspended matters thus carried onto the surface material. It is a well-known fact that there are periods in the operation of a septic tank usually subject to continuous quiet ebullition of gases, and with a relatively high subsidence efficiency, when of a sudden there rises to the surface of the sewage large masses of undigested suspended matters borne upward by the sudden release of a comparatively large quantity of gas confined under perhaps a heavy deposit of sludge. At such times, the suspended matters in the effluent increase abnormally and tend to choke the pores of the filters, and in certain cases cause the production of decided odors in and about the tank and the plant. This feature of the periodic upheavals in septic tanks, in many ways is, of course, a marked detriment to the process, owing to the load of finely divided suspended matters that are forced upon the oxidizing devices: it is, however, a condition which may be considered as inevitable in the case of most sewages and to a certain degree it would be desirable to provide means to prevent the damage which is caused by the sudden discharge of suspended matters in such large quantities. Generally, aside from surface baffles located near the outlet end of the tank, these being intended to cause the sewage in discharging to pass out with a minimum of disturbance, no special devices have been employed to reduce the suspended matters at the periods of unusually violent septic activity, and the effluent heavily charged with suspended matters passes on to the filters. At such periods filters of fine grain require especial care in their operation, and unfortunately for the general efficiency of the plants, the lack of attention they receive is in many cases deplorable. In the case of strong sewages it appears to be a difficult matter to control these fomenting periods in septic tanks, although tanks on the compartment plan and those operated in series may quite possibly be effective in some instances.

About the time sudden impetus was given to the construction of sewage plants by the rise in favor of the septic tank as a part of the design of such plants, considerable work was carried out, particularly in England, as to the feasibility of treating sewage in filters composed of fairly coarse grain material. The first of these were operated upon the contact plan, wherein the outlet of the filter is closed,

sewage admitted until the pores of the filter are filled, after which the sewage is allowed to stand for a stated period in contact with the filtering material, thus subjecting it to the action of the bacteria retained thereon. The contact filter will be recalled as a type of filter resulting from the increased knowledge of the bacteriology of sewage treatment brought forward particularly as, by its adoption, the purification of sewage was hoped to be the more economically accomplished in cases where fine grain material was scarce and where a limited area was available as a site for the sewage plant. As the head required for the operation of a sewage plant involving contact filters is less than that necessary for the most recent development—the sprinkling filter—there are many cases where the installation of a contact filter plant may successfully solve the problem of sewage purification especially where sand filtration is impracticable.

The efficiency of these plants varies considerably. In some instances the resulting effluents are carried to the non-putrescible stage as a result of the preparatory and the oxidizing treatment, while in others, the effluents of the contact filters possess considerable odor, are free from dissolved oxygen and protecting nitrates, and do not successfully pass tests for putrescibility.

In the majority of cases the effluents as discharged are low in suspended matters and hence of good appearance. This feature of the retention of the suspended matters of the applied sewage is characteristic of the contact filter and it is evident that the amount of suspended matter contained in the sewage applied to filters of this type controls in a measure their holding cleanings of the filtering material. Owing to the detrimental effect caused by flooding contact filters with a poorly prepared sewage, that is, an influent of high suspended matter content, the operation of contact filters in conjunction with septic tanks should be carefully watched. By taking advantage of the flexibility of the design of the preparatory devices, the endeavor should be so to operate them, that, changing conditions being met by modified operating procedures, the sewage applied to the contact filters may be as free as possible from suspended matter, never showing evidences of too prolonged retention, conditions which will tend to enable the contact filters to operate at their best with a minimum of clogging.

THE DEVELOPMENT OF ENGINEERING AND ITS FOUNDATION ON SCIENCE*

By SYLVANUS P. THOMPSON, D. Sc., F. R. S.

We live in an age when the development of the material resources of civilization is progressing in a ratio without parallel. International commerce spreads apace. Ocean transport is demanding greater facilities. Steamships of vaster size and swifter speed than any heretofore in use are being built every year. Not only are railways extending in all outlying parts of the world, but at home, where the territory is already everywhere intersected with lines, larger and heavier locomotives are being used, and longer runs without stopping are being made by our express trains. The horse cars on our tramways are now being mostly superseded by large cars, electrically propelled and traveling with greatly increased speeds. For the handling of the ever-increasing passenger traffic in our great cities electric propulsion has shown itself a necessity of the time; witness the electric railways in Liverpool and the network of electrically-worked tube railways throughout London. In ten years the manufacture of automobile carriages of all sorts has sprung up into a great industry. Every year sees a greater demand for the raw materials and products out of which the manu-

*Extracts from address to the Engineering Section G) at the Leicester meeting of the British Association for the Advancement of Science

facturer will in turn produce the articles demanded by our complex modern life. We live and work in larger buildings; we make more use of mechanical appliances; we travel more, and our traveling is more expeditious than formerly; and not we alone but all the progressive nations. The world uses more steel, more copper, more aluminum, more paper; therefore requires more coal, more petroleum, more timber, more ores, more machinery for the getting and working of them, more trains and steamships for their transport. It requires machines that will work faster or more cheaply than the old ones to meet the increasing demands of manufacture; new fabrics; new dyes; even new foods; new and more powerful means of illumination; new methods of speaking to the ends of the earth.

We must not delude ourselves with imagining that the happiness and welfare of mankind depend only on its material advancement, or that moral, intellectual, and spiritual forces are not in the ultimate resort of greater moment. But if the inquiry be propounded what it is that has made possible this amazing material progress, there is but one answer that can be given—science. Chemistry, physics, mechanics, mathematics—it is these that have given to man the possibility of organizing this tremendous development; and the great profession which has been most potent in applying these branches of science to wield the energies of Nature and direct them to the service of man has been that of the engineer. Without the engineer, how little of all this activity could there have been; and without mathematics, mechanics, physics, and chemistry, where were the engineers?

If, looking over this England of Edward the Seventh, we try to put ourselves back into the England of Edward the Sixth—or, for that matter, of any pre-Victorian monarch—we must admit that the differences to be found in the social and industrial conditions around us are due, not in any appreciable degree to any change in politics, philosophy, religion, or law, but to science and its applications. If we look abroad, and contrast the Germany of Wilhelm the Second with the Germany of Charles the Fifth, we shall come to the like conclusion. So also in Italy, in Switzerland—in every one, indeed, of the progressive nations. And it is precisely in the stagnant nations, such as Spain or Servia, where the cultivation of science has scarcely begun, that the social conditions remain in the backward state of the Middle Ages.

INTERACTION OF ABSTRACT SCIENCE AND ITS APPLICATIONS.

In engineering, above all other branches of human effort, we are able to trace the close interaction between abstract science and its practical applications. Often as the connection between pure science and its applications has been emphasized in addresses upon engineering, the emphasis has almost always been laid upon the influence of the abstract upon the concrete. We are all familiar with the doctrine that the progress of science ought to be an end in itself, that scientific research ought to be pursued without regard to its immediate applications, that the importance of a discovery must not be measured by its apparent utility at the moment. We are assured that research in pure science is bound to work itself out in due time into technical applications of utility, and that the pioneer ought not to pause in his quest to work out potential industrial developments. We are invited to consider the example of the immortal Faraday, who deliberately abstained from busying himself with marketable inventions arising out of his discoveries, excusing himself on the ground that he had no time to spare for money-making. It is equally true, and equally to the point, that Faraday, when he had established a new fact, or a new physical relation, ceased from busying himself with it, and pronounced that it was now ready to be handed over to the mathematicians. But, admitting all these commonplaces as to the value of abstract science in itself and for its own sake, admitting also the proposition that sooner or later the practical applications are bound to follow on upon the discovery, it yet remains true that in this thing the temperament of the discovery counts for something. There are scientific investigators who cannot pursue their work if troubled by the question of ulterior applications; there are others no less truly scientific who simply cannot work without the definiteness of aim that is given by a practical problem awaiting solution. There are Willanses as well as Regnaults; there are Whitworths as well as Poissons. The world needs both types of investigator; and it needs, too, yet another type of pioneer, namely, the man who, making no claim to original discovery, by patient application and intelligent skill turns to industrial fruitfulness the results already attained in abstract discovery.

There is, however, another aspect of the relation between pure and applied science, the

ance of which has not been hitherto so emphasized, but yet is none the less he reaction upon science and upon sci- discovery of the industrial applications. hile pure science breeds useful inven- t is none the less true that the indus- evelopment of useful inventions fosters gress of pure science. No one who is ant with the history, for example, of can doubt that the invention of the tel- and the desire to perfect it were the al factors in the outburst of optical sci- hich we associate with the names of ı, Huygens, and Euler. The practical tion, which we know was in the minds ı of these men, must surely have been pelling motive that caused them to con- e on abstract optics their great and onal powers of thought. It was in the -the hopeless quest—of the philoso- stone and the elixir of life that the tions of the science of chemistry were The invention of the art of photography ren immense assistance to sciences as apart as meteorology, ethnology, as- y, zoology, and spectroscopy. Of the f heat men were profoundly ignorant he invention of the steam engine com- scientific investigation; and the new of thermodynamics was born. Had been no industrial development of the engine, is it at all likely that the world ever have been enriched with the sci- researches of Rankine, Joule, Regnault, or James Thomson? The magnet had nown for centuries, yet the study of it terly neglected until the application of ie mariners' compass gave the incentive earch.

history of electric telegraphy furnishes striking example of this reflex influence istrial applications. The discovery of ctric current by Volta, and the inve-ti- of its properties appear to have been ited by the medical properties attrib- n the preceding fifty years to electric ges. But, once the current had been red, a new incentive arose in the dim lity it suggested of transmitting signals istance. This was certainly a possibil- n when only the chemical effects of the : had yet been found out. Not, how- ntil the magnetic effects of the current en discovered and investigated did tel- y assume commercial shape at the of Cooke and Wheatstone in England, Morse and Vail in America. Let us admit freely that these men were inventors rather than discoverers; exploiters of research rather than pioneers. They built upon the foundations laid by Volta, Oersted, Sturgeon, Henry, and a host of less famous workers. But no sooner had the telegraph become of industrial importance, with telegraph lines erected on land and submarine cables laid in the sea, than fresh investigations were found necessary; new and delicate instruments must be devised; means of accurate measurement heretofore undreamed of must be found; standards for the comparison of electrical quantities must be created; and the laws governing the operations of electrical systems and apparatus must be investigated and formulated in appropriate mathematical expressions. And so, perforce, as the inevitable consequence of the growth of the telegraph industry, and mainly at the hands of those interested in submarine telegraphy, there came about the system of electrical and electromagnetic units, based on the early magnetic work of Gauss and Weber, developed further by Lord Kelvin, by Bright and Clark, and last but not least by Clerk Maxwell. Had there been no telegraph industry to force electrical measurement and electrical theory to the front, where would Clerk Maxwell's work have been? He would probably have given his unique powers to the study of optics and geometry; his electromagnetic theory of light would never have leapt into his brain; he would never have propounded the existence of electric waves in the ether. And then we should never have had the far-reaching investigations of Heinrich Hertz; nor would the British Association at Oxford in 1894 have witnessed the demonstration of wireless telegraphy by Sir Oliver Lodge. A remark of Lord Rayleigh's may here be recalled, that the invention of the telephone had probably done more than anything else to make electricians understand the principle of self-induction.

In considering this reflex influence of the industrial applications upon the progress of pure science it is of some significance to note that for the most part this influence is entirely helpful. There may be sporadic cases where industrial conditions tend temporarily to check progress by imposing persistence of a particular type of machine or appliance; but the general trend is always to help to new developments. The reaction aids the action; the law that is true enough in inorganic conservative systems, that reaction opposes the action,

ceases here to be applicable, as, indeed, it ceases to be applicable in a vast number of organic phenomena. It is the very instability thereby introduced which is the essential of progress. The growing organism acts on its environment, and the change in the environment reacts on the organism—not in such a way as to oppose the growth, but so as to promote it. So is it with the development of pure science and its practical applications.

In further illustration of this principle one might refer to the immense effect which the engineering use of steel has had upon the study of the chemistry of the alloys. And the study of the alloys has in turn led to the recent development of metallography. It would even seem that through the study of the intimate structure of metals, prompted by the needs of engineers, we are within measurable distance of arriving at a knowledge of the secret of crystallogenesis. Everything points to the probability of a very great and rapid advance in that fascinating branch of pure science at no distant date.

NOTES ON THE DESIGN OF REINFORCED-CONCRETE BEAMS

FROM A BULLETIN ISSUED BY THE UNIVERSITY OF WISCONSIN.

1. Concrete reinforced with steel will not stretch more before cracking than plain concrete, and the unit elongation of the steel when the first tension crack appears is not greater than from [illegible] corresponding to a unit stress in the steel of [illegible]. Consequently the tensile resistance of concrete should not be taken into consideration in reinforced-concrete design.

2. That a method has been devised by means of which the [illegible] of a beam can be [illegible] determined [illegible] have been made [illegible] determining the position of [illegible] axis [illegible] different concretes and [illegible] of [illegible] purposes [illegible] working loads [illegible] good design [illegible] compression [illegible] to the tensile [illegible] vice versa [illegible] terna[l] stresses [illegible]

3. [illegible] beams [illegible] some provision must be [illegible] tensile stress from [illegible] compressive area of the concrete.

(4) This can be satisfactorily accomplished for simple beams by running half of the [illegible] of reinforcing bars straight through the beam and bending up the others at the loading points, half of the latter running to the top of beam at the end, and half to mid-depth of beam at end. The inclined cracks as they usually occur in a concrete beam are approximately perpendicular to the direction of these rods; and these rods are, therefore, very efficient in preventing this failure. In most reinforcement heretofore used with bent rods the angle of inclination with the horizontal has been too large, and, consequently, the adhesive area of the rods was too small. Numerous tests on both large and small beams have shown that these methods [illegible] in preventing inclined tension cracks.

[illegible] anchoring the horizontal rods at the [illegible] simple beam is of no benefit.

[illegible] sufficient provision made for [illegible] the strength of a concrete [illegible] calculated if the yield [illegible] metal and the compressive [illegible] concrete are known. The [illegible] compressive stress on the outer [illegible] taken somewhat larger [illegible] determined in cube form.

[illegible] good concrete and medium [illegible] factors of safety for con[illegible] of metal may be [illegible] without making [illegible] than the compressive [illegible]

RECENT ADVANCES IN REINFORCED-CONCRETE ENGINEERING

By ALBERT WELLS BUEL*

ıbstantial progress in the art of designing building in reinforced concrete has been rded in the articles indexed in "Technical rature" during the current calendar year. e of the contributions to the subject are ach importance as to merit a resurvey of present state of the art. In this connec- it is well to remember that progress is only indicated by satisfactory solutions of questions, but also by reopening ques- ı for discussion and scientific analysis that r practitioners have heretofore considered ettled.

ssibly the most far reaching, if not alto- er the most important step in designing 'orced concrete structures, is the tendency rd making the steel elements alone form mplete and stable structure. The Thirty- ı Street Building, completed in September is one example of this idea. If we have correctly informed, the steel in the col- s of this building was designed to carry f the loads—the concrete being only con- ed as a protective covering as far as the nns are concerned. This, if so, is cer- y on the safe side, but probably few will to adopt such extravagant construction.

ıe writer has proposed a middle ground, so costly as designing the steel for all of oads on columns, but yet with all the ad- ages of a complete and stable steel frame, perfectly safe. He would design the steel e throughout, including all bolted con- ons, so that for all loads, including those to erection, and without assistance from concrete, no part of the steel would be sed to over 32,000 pounds per square nor over, say, 24,000 pounds per square for erection loads only, reduced, where sary, by the usual formulas for flexure. For the finished structure, no part of steel should be stressed to over 16,000 ds per square inch, reduced by formulas, e required, and the concrete should be sd to, say, 600 pounds per square inch mpression and 75 pounds per square inch in shear, except where there is an excess of steel. Certainly the ratio of stress between the two elements in a compression member will be controlled by the ratio of their respective moduli of elasticity, and if it were not that the steel element, in a design of this class, may be given an initial load before the concrete is placed, there might not be sufficient advantage to justify it in comparison with designs of the McGraw building class. This is admittedly a complex feature of the principle proposed, and the only thing that can be said about it is that each case should be treated on its merits by qualified experts. Other "systems," however, have no less need of expert treatment—rather more- since the principle here outlined is intended to provide a steel frame that will be in stability for all conditions of loading irrespective of the concrete. The concrete supplies the protective covering and at the same time relieves the steel of excess load and stress.

Another recent example on this line is that shown in an illustrated communication from Mr. John M. Ettler in the "Engineering Record" of August 31, 1907—page 246. This describes the reinforcement of the Owl Drug Co.'s building on Mission street, San Francisco, Cal., as follows: "The method of reinforcement marks an innovation in that the steel work forms a complete unit before any concrete is put in place. This unit is so completely formed that it is quite practicable to erect all steel work before any concrete is poured. Among the advantages of this method of construction, the following may be mentioned: The steel forms a complete structural unit in itself and does not cause internal stresses in the concrete, allowing the latter to perform the functions for which it was designed. Defects in the steel work cannot escape notice, and there is little likelihood of derangement of the steel during the pouring of the concrete. The design can be computed readily and permits very quick erection."

The "Engineering Record" of August 10, 1907, page 162, prints an illustrated descrip-

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*ber of Part I., "Reinforced Concrete."

tion of "A System of Structurally Reinforced Concrete"—patented, in which the complete steel frame is the main idea. This is encouraging, not only as an indication that a number of men are working for solutions of the problem along the lines herein outlined, but also because it permits us to hope that some will find it commercially profitable to exploit systems designed on safe principles.

Prof. Lewis J. Johnson, in a discussion at a recent meeting of the Boston Society of Civil Engineers, advocated the use of top reinforcement in beams and slabs, primarily to provide for the negative moment at the supports due to continuous beam action. (See "Engineering Record" of September 28, page 351). That there is generally more or less restraint at the supports, and that it is often statically indeterminate, will be quite generally admitted, as will be the fact that in many cases no proper provision has been made for the negative moments. It is correctly pointed out that the top reinforcement is of the greatest possible value in case of weakening of bottom rods by fire. The top rods, through cantilever action, may carry the load after the far more exposed lower rods have failed. Irrespective of fire hazard, the top reinforcement increases the margin of safety, and may properly be taken into account in designing the section, thus effecting a saving of a part of its cost. If this principle comes to be generally adopted, it will greatly assist in the introduction of the complete steel frame system of reinforcement.

The most notable example of progress in methods of construction is furnished by the two new kiln houses of the Edison Portland Cement Co., at New Village, N. J., an excellent illustrated description of which is given in "Engineering News" for July 4, 1907, pages 5 to 9. These buildings were constructed entirely with separately molded members, cast on the ground from four to six weeks before being erected in place.

This method has been used to some extent in Europe, and reports of it have been favorable. Although we have in America one or two examples of Visintini construction, in which beams and girders are separately molded, the method has not as yet received the attention it seems to merit.

The experience gained with these buildings of the Edison Portland Cement Co. will be very valuable to those contemplating the use of this method, particularly in regard to provisions and devices for safely lifting and handling the members. A device worthy of imitation is that of first casting the roof slabs on a cinder bed, to form the molding floor for the other members, afterwards taking them up and setting them in position on the roof.

When the ground area for molding and casting the members near the building site is not available, the cost of transportation must be considered. It has been stated that it costs no more to transport the finished members than the cement and aggregates for concrete. The cost of the forms and of mixing and placing is considerably less than with monolithic work molded in place. It would also seem that labor conditions should favor the method of separately molded members.

The "Engineering News" states that the two buildings of the Edison Portland Cement Co. will be finished at a total (estimated) cost approximately $4,000 less than two steel buildings of the same type. Some other advantages of the method are that the mixing and placing of the concrete are under more perfect control, resulting in a more uniform and reliable product. Tests to destruction may be made on extra members before the other members of the lot are erected in the structure. Test cubes or coupons may be made to represent as many of the batches or members as desired. The method permits close supervision and inspection. The concrete can be kept thoroughly wet while hardening, and no member need be erected until sufficiently aged, thus minimizing the danger of subjecting green concrete to stress. A rapid extension in the application of this method may be confidently expected.

Some intelligent efforts are being made to formulate rules, codes or specifications for design and construction in reinforced concrete. These submitted to the Building Code Revision Commission of New York City by the Concrete Association of America, the new Building Code of San Francisco and "Some Essential Requirements in Reinforced Concrete Work" by Mr. Frank B. Gilbreth, "Engineering News" of August 29, 1907, page 230, deserve mention, notwithstanding that they are open to criticism on some points and seem to have failed to comprehend the full import of past experience, (including some failures) and of recent experiments.

The report of the Joint Committee of British Architectural and Building Associations and government bureaus, together with its appendices, "Engineering Record" of July 27 and August 3, 1907, is more pretentious and perhaps more comprehensive. While some of

its conclusions are quite different from what a similar American committee might be expected to arrive at, in view of the experience and experimental data available, others are somewhat in advance of the present practice here. The report begins with the sentences, "Reinforced concrete is used so much * * * that a general agreement on the essential requirements of good work is desirable," and, "Good workmanship and materials are essential. With these and Good Design, structures of this kind appear to be trustworthy." This would be all right, almost ideal, if there was any practical way to eliminate all bad designs.

The report states that "there is no reason to fear decay of the reinforcement in * * * cinder concrete made with clean, fresh water, if the metal skeleton be properly coated with cement." An article in "Engineering News" of May 23, 1907, page 569, by Mr. Wm. H. Fox, gives results of experience and experiments showing serious corrosion in cinder concrete and says, "A rich mixture, either a 1:1.3 or one in which the proportion of cement to aggregate is larger, should be used in all cases. The greatest of care should be taken in mixing the materials, and it may be necessary to resort to the seemingly impractical method of coating the reinforcement with grout before placing in the concrete * * *. It is quite evident that cinder concrete should be used only with a view toward the possibility of future corrosion."

The report gives considerable attention to the question of fire resisting qualities, and to materials and proportions. Of the three highest fire resisting materials recommended for the aggregate, slag will undoubtedly give the strongest and best concrete.

The specification for sand is about the best that has been proposed. All sand is required to pass a ¼-inch mesh and 75 per cent. of it a ⅛-inch mesh. It is required to be clean, but washing, it says, does not always improve it, as the finer particles which may be of value to the compactness and solidity of the mortar are carried away in the process. Sand briquette tests, it points out, are better than mere appearance in judging the value of a sand. It recommends that the aggregate pass a ¾-inch mesh and be retained on a ¼-inch mesh.

The proportions of cement to sand and aggregate must be such that the cement at least equals the voids in the sand and gives the required strength and that the mortar be at least 10 per cent. more than the voids in the aggregate. It recommends that the voids in both sand and aggregate be measured as well as the "volume of mortar produced by the admixture of sand and cement in the proportions arranged." This is by far the best specification on these points that has yet been published in complete form. The writer has used a similar method for ten years and briefly described it in Part I of "Reinforced Concrete."

An allowance for shock is recommended, equal to half the accidental load for public halls, factories, etc., and equal to the accidental load for floors carrying machinery, the roofs of vaults carrying passage ways and courtyards.

In view of American experiments as well as of the Hyatt-Kirkaldy tests, undue importance seems to be given to bending up the ends of rods and other forms of end anchors.

For high steel one-half the stress at the yield point is recommended as the allowable tensile stress. This will permit some rather high working stresses, but, with the provision of allowances for shock, they are probably justified.

Of the appendices, that written by Prof. A. C. Unwin on slab theories will, no doubt, receive the most attention in this country, where this subject has already become a live topic for discussion. Prof. Unwin compares Grashof's and Rankine's Rule with the French Government Rule and with Bach's Theory, but an entirely satisfactory solution has not yet been presented. Bach's theory does not seem to give uniformly distributed reactions. It appears to require the reinforcement to be perpendicular to the diagonals.

The Grashof-Rankine and French Government rules are applicable to slabs with reinforcement parallel to the sides and ends, that is, transverse and longitudinal. This would seem to imply reactions greater at the centers of the sides and ends than at the corners, and greater for the long sides than for the short ends. With transverse and longitudinal reinforcement, it is not clear how an element can receive any increment of load or moment on the central part of its length intercepted by the diagonals of the rectangle. This, of course, refers to uniformly distributed loads only.

If the reinforcement were arranged parallel to the diagonals, each of the sides and ends would appear to have the same amount of reaction and uniformly distributed from corner to corner, the intensity along the ends being

greater than along the sides in the inverse ratio of their lengths.

It is probable that smaller rectangles, with diagonals coincident with those of the slab, will mark lines of equal deflection and that, therefore, the part of the length of elements coincident with a side of such inscribed rectangle will not be subject to increment of load or moment.

The authoritative solution of this problem seems to require the attention of the laboratories and theoretical investigators, and, for the present, the best plan for the ordinary constructor to follow is to make his slabs safe. The Grashof-Rankine rule is more conservative than the others, and is applicable to the usual case of transverse and longitudinal reinforcement. For reinforcement on lines parallel to the diagonals, or perpendicular to them as indicated by the Bach theory, the form of expanded metal disposes the reinforcing metal nearly on theoretical lines.

Where the length of the slab exceeds twice its width, it should be designed as a simple beam for a length of span equal to its width.

THE DANGERS OF CONTACT WITH ELECTRICAL CURRENT

In a recent issue of the "Chemiker Zeitung," Herr Hermann Zipp, lecturer at the Municipal Polytechnic at Cöthen, discusses the danger to human life introduced by accidental contact with an electrical current, and comes to the conclusion that the extent of the injury is not entirely due, as is generally imagined to be the case by non-technical people, to the voltage of the current, but partly or mainly depends on the quantity of electricity which is caused to flow through the human body and upon the parts of the system to which it penetrates. The experiments that have been carried out on the physiological influence of electrical currents show that a part of their effect is due to their electro-chemical action upon the liquids of the body, and part to the injury done to the most important organs by contact with the current of electricity. The following facts have indeed already been established: (1) When a current flows from hand to foot under the worst conditions, that is to say, when a man's boots are thoroughly soaked with water and his hands are damp, the resistance of the human body is on an average 5,000 ohms. (2) When an alternating current of 5 milliamperes with 50 complete alternations per second flows through a person, the effect is sufficiently marked to produce muscular contraction; hence in the author's opinion a current of from 50 to 100 milliamperes must be undoubtedly considered as dangerous to life provided it comes into the neighborhood of the most important organs of the body. In judging of the degree of danger exhibited by any electrical installation, therefore, the investigator has to inquire whether it is possible that a current of such volume can be introduced into the human system from any part of the plant. The chief sources of danger are, of course, a broken conductor, too highly charged a conductor, and the effect of lightning; but the following points have also to be borne in mind, viz., bad insulation or high capacity in items of the plant, and the conversion in a transformer of a high tension current into one of low voltage.

The author accordingly proceeds to discuss the various accidents that have arisen, or are liable to arise, under four separate headings. (1) Simultaneous contact with both conductors. (2) Contact with only one conductor. (3) Contact with the "charging current" in alternating installations; and (4) Dangers introduced during the reduction in voltage of a current.

1. Simultaneous Contact with both Conductors.—In certain conditions, e. g., a chemical factory or a mine where the atmosphere, etc., is damp a man may be injured by contact with a 110-volt current; because his personal resistance, being lowered to 5,000 ohms, as already stated, he may receive a current of 25 milliamperes therefrom. It is even possible in some cases, where the air is loaded with acid vapors, that the conductivity of the human

may be greater still, so that death may :aused by contact with a current of 110 . In practice, however, this circumstance not involve great risk, because it is more to eliminate the dangers attendant upon electrical plant than those of any other of machinery.

a large number of cases simultaneous act with the two wires of a circuit pro- no effect at all, either because the man's is dry, and so forms an excellent insula- or because the current passes without ing near any critical organ. For exam- some time ago the writer himself acci- tally placed one hand between the two act pieces of a 1,000-volt transformer in conditions that the current passed for a ance of about 2 in. through his flesh. The t was a severe shock to the system and a nentary combustion of the skin, but no her ill effects followed. If, however, the tact had been made with both hands, a ent equal to 100 milliamperes would have ed through his system even if his resist- e had been as high as 10,000 ohms, and th would have certainly resulted. It is, efore, clear that arrangements should al- s be made to prevent the possibility of ultaneous contact with both conductors of rcuit, either by compelling the men to wear ber shoes and gloves, or preferably, the plete suit of clothing designed by Prof. emieff. This consists of a garment woven of stout linen with a layer of fine copper e, and is so formed as to enclose the whole y. If a man wearing this clothing makes tact with both high-tension conductors, the rent passes via the copper wire, and prac- lly none enters his system.*

. Contact with One Conductor.—When a makes personal contact with the two con- tors of an electrical circuit simultaneously, rly always gross carelessness is involved; it is a much commoner thing for him to ch one of the conductors. Inasmuch as no fect insulator exists, at every spot where onductor is supported, some leakage of cur- t to the earth occurs. The amount of leak- at any single insulator is negligibly small, in a very long circuit, where large num- of insulators are employed, especially in amp atmosphere or one charged with acid ors the total losses of current are serious. . if a man standing on the damp ground hes one of the conductors, a current passes from the wire, through him, to earth, and returns via the numerous insulators of the other conductor; and the greater the number of insulators on the circuit, the more dangerous is the current that enters his body. In this particular case, clearly, it is not the voltage of the current which is of chief importance, but length of the conductors in the circuit that are supported on insulators. The case mentioned above where a man received a fatal shock by contact with the wire cage of a glow lamp, could only have occurred in an extensive electric system, provided, of course, that the wiring had been done properly. The author has intentionally touched the wires of an alternating electrical circuit about 150 ft. long in which the pressure of the current ranged between 3,000 and 5,000 volts. The insulation of the conductors not being defective, he experienced no ill effects; but had the circuit been several hundred feet longer still, some harm would have been done to him. Hence it follows that arrangements should be made preventing the possibility of contact with a single conductor of any electrical plant, even if the pressure is low, except under such conditions as when a man has his hands or feet properly insulated.

3. Contact with the "Charging Current" in Alternating Installations.—When the two coatings of a Leyden jar are connected with the poles of an alternator they receive alternately positive and negative charges, and the quantities of electricity necessary to produce these charges must flow through the wires. The quantities of electricity pulsating in the wires under the conditions mentioned, may be termed "charging currents," and are sufficiently large to be indicated by an amperemeter or, if the Leyden jar is large enough, by causing an incandescent lamp to glow. The larger the size of the Leyden jar, i. e., the condenser, the larger are the amounts of electricity stored in it, and the larger is the charging current. Every conductor of electricity forms such a condenser with the earth; and if a man touches one conductor, his body acts as the wire of the condenser, conveying the charging current to earth. The other coating of the condenser is the untouched conductor, and is obviously connected with the source of alternating current. Hence through the body of the man flow the charging currents of the condenser which is formed of the earth and the second conductor, and if the latter is large enough, that is to say, if the conductor is long enough, the charging current may be of suffi-

*he fact that this garment might become a veritable of Nessus, in the shape of a coat of fire, seems to been overlooked.—Eds. Electrical Review.

cient volume to cause death. This charging current is the chief cause of fatal accidents when contact is made with a single high-pressure wire, because the currents due to faults in insulation, which have been previously discussed, are usually far too small in amount to be of importance. In the particular case now under contemplation the length of the distributing system is far more serious than the voltage; and it may, therefore, be said that every high-pressure installation is dangerous when only one conductor is touched, provided a man's hands or feet are not well insulated. Armored lead cables are especially dangerous, owing to their high capacity, and contact with them is likely to produce worse results than contact with a naked wire.

From what has already been stated, it is evident that, more particularly in cases where the installations are employed in a moist atmosphere, there is danger, not only in simultaneous contact with both conductors, but also in contact with one. Escape of current is particularly liable to occur from badly-built switchboards and similar apparatus, although such escape can easily be prevented by proper construction. It is very necessary that new installations or enlargements to existing plants should only be made under the supervision of men who understand the matter thoroughly.

4. Dangers of Transformation.—In this section of his article Herr Zipp briefly refers to the danger experienced by a man who receives a current in the neighborhood of a transformer. As the insulation of a high-tension circuit is much better than that of a low-tension circuit the current which always tends to escape from the former to earth often finds it easier to pass first to the low-tension circuit, and then to earth. If, now, the resistance between a low-tension circuit and the earth is 20,000 ohms, and a man, the resistance of whose body is 10,000 ohms, approaches that circuit, he may receive a part of the current which is on its way via the low-tension circuit from the high-tension circuit to the earth. The risks, indeed, are practically the same as those when direct contact with a high-tension circuit is made accidentally.

In a final paragraph the author refers to the very high voltages (namely, such as 100,000 volts), which are not dangerous to man when the frequency of the current is very great, reaching, for example, 100,000 alternations per second; and he ascribes the harmlessness of these Tesla currents to their passage along the outer surface of a conductor, so that when the conductor in question is a human being the critical organs of his body are not affected by them.

In a later issue of the "Chemiker Zeitung" Dr. H. Danneel, of Friedrichshagen, criticises certain features of Herr Zipp's article. He takes it for granted that the physiological effect on the human body of an electrical current is due to electrolysis, i. e., to the migration of the ions in the living cells. Hence the only important question is the number of coulombs of current which enter the system, not the number of amperes. He, therefore, regards the harmlessness of Tesla currents as due to the extremely minute quantity of electricity per phase, which causes the alternation in concentration in the cells of the human body to be insignificant. In a brief rejoinder Herr Zipp disputes the accuracy of the purely electrical view propounded by Danneel. As stated in his main article, he attributes much of the effect of an electrical current upon a person to its electro-chemical action, but the influence on the nerve centers—that is to say, the shock produced by the current—must not be neglected; and the magnitude of this shock would appear to be, to some extent, a function of the voltage.—"Electrical Review," London

THE VENTILATION OF WORKSHOPS*

The present report has been prepared with a view chiefly to furnishing some general guidance as to the application of fans to the ventilation of factories and workshops. Experience has shown that serious mistakes are frequently made in the design of fan ventilation; and we therefore hope that a short and elementary account of the subject, with diagrammatic illustrations, may prove of service to those owners and managers of factories and workshops who are not already familiar with the principles involved.

Selection of Fans.—Although fans of excellent construction, and driven either electrically or by pulleys, can now be very easily obtained, it must be clearly borne in mind that different types of fan are made for different kinds of work, so that a fan which is very well suited for one purpose may be quite unsuited for another. Broadly speaking, fans may be divided into: (1) Low-pressure fans, those designed for moving air against very slight resistances (the difference of pressure on the two sides of the fan not exceeding, say, ¼ in. of water as measured by a water gage); and (2) high-pressure fans, working against resistances which may mount up to several inches of water. The resistance due to the passage of a given volume of air through the fan itself is, size for size, very much smaller in the former than in the latter class. Hence, if the high-pressure fan is used to drive air against a low external resistance, practically the whole of the power expended may be wasted in overcoming the internal resistance of the fan. On the other hand, if a low-pressure fan be used against a high external resistance, the quantity of air passed will be very small, and the power will be thrown away in friction and the production of eddies about the fan.

Low-Pressure Fans.—When air requires to be moved against very slight pressure, the so-called "propeller" fan is usually employed, although low-resistance centrifugal fans can also be advantageously used in some cases. In the propeller type of fan the blades are arranged similarly to those of the screw propeller of a steamship, the air being driven forward by their revolution. By this means enormous volumes of air can be delivered through the fan with a very small expenditure of power, provided there is little or no resistance on either side. For a good type of propeller fan working under practical conditions, with unimpeded flow of air, Mr. W. G. Walker gives the following convenient formula as the result of a number of experiments:—

$$\text{Horse-power} = \frac{Q^3}{D^4} \times 0.0000115;$$

where Q = quantity of air discharged in cubic feet per second, D = diameter of fan in feet.

Thus with a discharge of 12,000 cu. ft. per min., or 200 cu. ft. per sec., and a 4-ft. fan, the horse-power required would be $\frac{200^3}{4^4} \times 0.0000115 = 0.35$. This example will give an idea of the very large volumes of air which can be moved by a propeller fan with a trifling expenditure of power, provided there is no resistance.

The air delivery by a propeller fan varies in direct proportion to its rate of revolution, while the power needed to drive it varies as the cube of its velocity. Hence for a given expenditure of power much more air is propelled with a low than with a high rate of revolution. In practice, however, it is best to run a fan at a considerable velocity; otherwise the flow of air may easily be greatly diminished, or even reversed, by the influence of wind.

With increasing resistance the air delivered by a propeller fan rapidly falls to almost nothing, although considerable power is being expended in driving it. The waste of power is due to the fact that air passes back through the center of the fan, where the velocity of the blades is low, and the work done by the tips of the blades is absorbed in merely expelling this same air.

The resistance may be due (apart from the influence of wind or of insufficient inlet openings to the room) to construction of the ducts, inlets, or outlets connected with the fan, to sharp bends or rectangular junctions with branch ducts, and to friction along the sides of ducts. If the sectional area at any part of a duct conveying air to or from a fan be reduced to less than the sectional area of the fan, it is evident that the linear velocity of the current at this point will be correspondingly greater

*From a recent report to the British Home Department

than at other points in the duct. But the work expended in setting air in motion varies as the square of the velocity, and any considerable narrowing of a duct thus introduces a resistance which a propeller fan cannot overcome, with the result that the power applied to the fan is wasted. It is a common mistake to suppose that by constricting a duct leading to or from a propeller fan a materially greater velocity of air current can be obtained. The influence of the constriction is simply to diminish the flow of air. Another source of resistance is any sharp bend in a duct. A rectangular bend practically doubles the pressure needed to merely set the air in motion in the duct, and a rectangular junction with a branch duct has a similar effect. A loss about half as great also occurs at the inlet opening of a duct unless it is trumpet shaped. Resistance due to friction along the walls of a duct is proportional to the total internal surface of the duct, and to about the square of the linear velocity, but inversely proportional to its sectional area. It becomes a serious item if long and narrow ducts are employed, and such ducts should always be avoided where propeller fans are used. Frictional resistance depends also upon the roughness of the internal surface of a duct, and these surfaces should be as smooth as possible. The narrowing of ducts by deposits of dust should also be carefully avoided, and the better to ensure this when ducts are being constructed ample provision should be made at suitable points for the easy removal of dust and other accumulations.

High-Pressure Fans.—Where air currents of high velocity are needed, as, for instance, in exhausting the dust from wheels used in dry grinding, or where narrow or tortuous ducts cannot be avoided, it is necessary to have fans capable of working effectively against considerable resistances. For this purpose centrifugal fans are usually employed. In the centrifugal fan the air inlet is at the center of the fan, which is enclosed in a metal case, and the air is driven outwards in a tangential direction by the revolution of the blades into a space between their periphery and the case. As the outline of the case is somewhat like that of a snail's shell, this space gradually increases in cross-section towards the air outlet, so that the air passing outwards between the blades can escape freely at all parts of their revolution, and travel round the case to the outlet. A trumpet-shaped prolongation of the latter increases the efficiency of an exhaust fan.

According to the details of construction, centrifugal fans may be suited to deliver, with a given expenditure of power, either large volumes of air against a relatively low resistance, or smaller volumes against a relatively high resistance; and in selecting a fan the volume of air required, and the resistance against which it has to work, must be carefully considered. Centrifugal fans suited to work against the higher resistances have also a relatively high internal resistance, so that if they are set to work against a low resistance in ducts, etc., the energy is wasted on the internal resistance. Details with regard to the capacities of various types of fan may be obtained from the makers, who should specify the volumes of air delivered, as measured by an anemometer, with different resistances measured by a water gage, together with the corresponding horse-powers required to drive the fan.

The resistances which have to be overcome by pressure fans are, of course, due to the same causes as in the case of propeller fans; but in practice the factors involved often differ in relative importance in the two cases. Thus the ducts connected with a pressure fan are usually longer in proportion to their cross-section, so that resistance due to friction is more important. There may also be many unavoidable bends in them. They are usually best made of metal pipes with smooth internal surface, all sharp rectangular bends or junctions being avoided and no leakage permitted; unless these points are attended to, resistance due to friction, etc., may mount to a very serious extent. On the other hand, the comparatively small resistances due to such causes as wind pressure, restricted inlet openings to a room, etc., are of much less importance than when a propeller fan is used.

Volume of Air Required, and Arrangement of Inlets and Outlets.—In designing any system of fan ventilation the first points to consider are the quantity of air required and its proper distribution. The quantity depends to a large extent on the distribution; and in many cases a relatively small quantity well distributed is far more effective than a large quantity badly distributed.

General Ventilation.—Certain impurities can hardly be prevented from becoming generally distributed in the air of a room, and can thus only be dealt with by general ventilation of the room. In most cases this is true of the products of respiration and of combustion of gas, the water evaporated in wet processes,

and the heat given off from the moving or artifically heated machinery; and in some cases of the production of dust. In removing these impurities or sources of inconvenience the supply of air must be sufficient for the particular purpose in view. If, for instance, heat or dust has to be removed, the ventilation must be sufficient to effect this removal, and not merely to dilute the products of respiration.

As regards impurities from persons and lights, the legal standard proposed by this committee in its first report was such as would prevent the proportion of CO_2 from respiration or combustion from ever rising beyond 12 volumes per 10,000 of air during daylight, or beyond 20 volumes at night with gas burning. If the distribution of air were perfect and constant this would imply a minimum ventilation by day of about 1,250 cu. ft. of air per person and per hour. Since, however, the distribution is always more or less imperfect and liable to be interfered with by varying conditions of weather, about double this quantity of air would usually need to be supplied in order to conform to the standard. If more than about 2 cu. ft. of gas per person and per hour were burnt in the room (or one flat-flame jet to three persons) an addition of about 1,500 cu. ft per hour for each extra flat-flame jet would probably be needed.

The quantity of air required to remove excessive heat and moisture cannot well be calculated in the same way, as the loss of heat through walls and roof is usually not known, and in any case varies with the weather. The air supply must therefore be regulated with the help of thermometers. Air in which the reading by the wet bulb thermometer exceeds about 70° begins to cause serious inconvenience with ordinary clothing, and this limit ought not to be exceeded in factories or workshops except under exceptional conditions.

Experiments show that if the wet bulb reading rises beyond about 88° in fairly still air, the body temperature can no longer be prevented from rising seriously even in persons stripped to the waist and doing no work; and with muscular work under the same conditions the body temperature may rise rapidly at a wet bulb temperature of 80°. With ordinary clothing this effect is considerably greater. At the upper limits it is not the temperature of the air, but that of the wet bulb thermometer that matters, and provided that the air is so dry that the wet bulb temperature does not exceed the limits specified, air temperatures up to 120° or more can be tolerated without rise of body temperature.* Much higher wet bulb temperatures can, of course, be borne for short periods, but the body temperature soon rises seriously.

In removing steam from rooms it must be borne in mind that cold air is apt to cause condensation of aqueous vapor. Thus if air saturated with moisture at 80° is mixed with even 10 times its volume of air from outside at 40° condensation will nevertheless usually occur, and will always do so, whatever the dilution, if the incoming air is saturated with moisture at the outside temperature. If, however, the incoming air be warmed to a moderate extent as it enters, this condensation will be prevented, and the ventilation will serve the double object of cooling the room and preventing condensation. If it is only necessary to prevent condensation of vapor, and not to remove heat, the object can often be best attained by providing not extra ventilation, but heating arrangements. In the case of dyeworks, etc., where the building is often filled with steam from the vats, experience shows that the atmosphere is best cleared and condensation avoided by blowing in air heated by passing through a coil or other form of radiator.

As regards removal of dust, the standard of purity aimed at should always be sufficient to prevent injury to health, and should also be such as to prevent inconvenience and enable those employed to be clean when they leave work, after washing, if necessary. Dust from the disintegration of hard stone, steel grinding, etc., is extremely deleterious, and the same may be said of dust containing any poisonous constituent, such as lead.† In such cases the dust should, by special means, apart from general ventilation, be entirely prevented from mixing with the general atmosphere of a room, and the same remark applies to all poisonous gases and fumes.

The effect of ventilation on the temperature of a working room during cold weather needs

*The following observations made recently by Dr Haldane will illustrate this statement. With the air temperature at 131° and the wet bulb at 88°, the body temperature remained the same after 2¼ hours. With the air temperature at 90° and the wet bulb at 89° on the other hand, the body temperature rose nearly 3° in the same time, and with the air temperature at 94° and the wet bulb at 94° the body temperature rose 4° in two hours. The subject, who was the same in each of the experiments, was stripped to the waist, and resting. With moderately hard work and a wet bulb temperature of 87° the temperature rose 4° in one hour.

†It is sometimes difficult to say whether the inhalation of a given variety of dust is definitely injurious. Dust from any hard stone (such as flint, granite, sandstone, etc.) is undoubtedly very injurious to the lungs, producing a marked predisposition to phthisis. On the other hand coal dust, cement dust, and probably many other varieties of organic and inorganic dust have by no means the same serious effects.

careful regulation. For sedentary work and fine manipulations a temperature of not less than about 60° is required. With lower temperatures the working powers of those present become impaired; and the effects of the low temperature are much increased by drafts. On the other hand, if the work implies active exertion lower temperatures are permissible, and some kinds of work associated with dust, fumes, etc., can best be performed in sheds open to the air. In general, the more nearly open-air condition can be attained to in any class of work the better; and whenever possible, windows should be thrown widely open in summer weather.

In general ventilation by fans the air may be either blown in (so called "plenum" system) or exhausted. The one or the other system may be most suitable according to circumstances, and in some instances the combination of both systems is desirable and most effective, as in the French or so-called dry cleaning, where the fumes of benzole, etc., require to be locally exhausted and fresh air supplied. The exhaust system is much employed on account of its simplicity, especially in sparsely occupied rooms, the air being exhausted by one or more fans placed in windows, walls, or roof, and allowed to enter by suitably-arranged openings distributed at other parts of the room. The main advantages of this system are that no ducts are needed, and that the fan causes no draft in its neighborhood, while the cold incoming air causes little draft if given an upward direction so as to mix with the warm air of the room above the heads of the occupants. A fan or exhaust opening of any kind draws its air supply from all round without causing a draft in a particular direction. When, however, air is entering through a fan or other inlet it is driven in a definite steam straight forwards owing to the momentum which has been communicated to it.

With exhaust ventilation corresponding inlet openings are essential, apart from the chance opening of windows or doors. The inlet openings should have a total sectional area equal to or greater than the fan opening, and should direct the air upwards so as to avoid drafts. Although a considerable amount of air may enter through the walls, etc., of a room, this quantity is usually insufficient, and owing to the neglect of inlet provision exhaust propeller fans may often be seen wasting most of the power communicated to them and producing no satisfactory result. The inlets should be so placed that the whole room is properly supplied with fresh air, the incoming air not being allowed to pass straight to a fan without displacing a due proportion of the foul air of the room. It is often a distinct advantage to have the exhaust outlet at the floor level. With this arrangement dust and particulate matter, including that from the mouths and persons of those present, are more effectually removed, since all particulate matter tends to fall. Loss of heat from the room is also diminished, as air at the floor level is colder. On the other hand, hot air and the products of combustion of gas are best removed by an outlet opening higher up.

The "plenum" system of ventilation possesses the advantage that the incoming air can be warmed or cooled as it enters, and if necessary moistened, or filtered free from smuts by passing it through coarse jute, cotton cloth, or other efficient filtering material, placed diagonally or zigzag in the inlet duct so as to give large filtering surface. As the draft is in an outward direction at all other openings than those through which the fan delivers air, there is complete control over the quality of the air entering the room, and no chance of air being drawn in from contaminated sources. As regards the position and direction of inlets and outlets, the same considerations apply as in the case of exhaust ventilation.

GAS LIGHTING AND HYGIENE*

By VIVIAN B. LEWES, F. I. C., F. C. S.

The effect of burning coal gas as an illuminant on the air of our dwelling rooms and the health of its occupants is as old a subject as the use of coal gas itself; and in the early days of the gas industry it threatened to wreck its future for indoor illumination, as the crude gas then sent out, rich in sulphuretted hydrogen, gave rise to such discomfort when consumed, that ventilating burners of clumsy device had to be employed for its use, while badly made and leaky fittings gave at all times an aroma which suggested to the nose and mind of the householder a doubt as to the sanitary condition of the drainage.

A very short period, however, served to convince the gas manager that the purity of the gas was a matter of even greater importance to him than to the public, as the latter could escape the effects of the sulphurized products of combustion by adopting other illuminants; while the gas manager's livelihood depended on keeping his customers. As a result, purification from sulphuretted hydrogen was adopted, and the use of coal gas increased with enormous rapidity.

With the advent of the electric light as an illuminant, great stress was laid upon its enormous advantages from the hygienic point of view; and its supporters still make the claim that it must of necessity be far more healthful to use as an illuminant than coal gas. It has not unnaturally been assumed that, owing to incandescent electric lighting adding nothing to the impurities in the atmosphere, and—what is quite as important—withdrawing no oxygen from it, it must be the most hygienic form of illumination to employ; but in the years which have elapsed since electricity was pressed into the service of man for illuminating purposes, it has become perfectly clear that, though it is inactive as regards vitiation of the atmosphere, a gas lighted room will nearly always be more pleasant and healthy to live in than one lighted by the newer form of illuminant.

I have in my mind at the moment a hall, which in the old days was lighted by gas, and in which a large audience could with comfort sit through an hour's lecture or with pleasure through a three hour's dinner, but which, with the march of civilization, had its illumination changed from gas to electricity; the latter being employed with all the latest refinements to effect the lighting under the best conditions, with the result that any large gathering within its walls leads to a state little short of asphyxiation.

In all processes of ventilation, the great factors which enable us to change the atmosphere in our dwelling rooms are the air currents set up by alterations in temperature and inter-diffusion between volumes of air at different temperatures; and it is this which gives coal gas its great advantages as an illuminant over electric lighting. Using an incandescent mantle on an atmospheric burner, about 4 cu. ft. of gas per hr. are consumed; and this gives 2 cu. ft. of carbon dioxide, which would very soon suffice to raise the proportion of carbon dioxide above the sanitary limit of 6 parts in 10,000. But though everything be done to render the room as air-tight as possible, it will be found that the proportion of carbon dioxide is enormously less than it should be by theory; this being due to the fact that alteration in the temperature of the air of the room sets up currents and actions which tend to bring about a change of the atmosphere.

The Value of Diffusion.—Carbon dioxide is a gas considerably heavier than air; so much so, indeed, that it can be poured from one vessel to another almost like a liquid. But, like all other gases, it is expanded by heat; and as the foul air coming from the lungs, and containing some 5% of carbon dioxide, is at practically the temperature of the body—i. e., 98° F.—it at once rises towards the ceiling, while the products of combustion from the gas burner, being at a still higher temperature, also rush up to this point, so that the foul air is always to be found at the top of the room. One might think this foul air when cooled down would descend into the room again. But here comes into play the process of diffusion—a process by which gases, instead of arranging themselves, like other forms of matter, according to their weight, undergo a mingling or diffusion, the rate of which is dependent upon their weight; a light gas mixing rapidly with others, while a

*From a lecture delivered at the June meeting of the British Institution of Gas Engineers.

heavy one diffuses more slowly. It is found that, once mingled, the gases remain in perfect admixture; so that in the present case the heavy carbon dioxide will not again separate from the air into which it has become diffused.

This so-called diffusion of gases will take place with even greater rapidity through porous solids than when the gases are left simply in contact with each other; and as the plaster of the ceiling and the bricks or other building material of which our walls are composed are full of minute openings or pores, they allow gases to diffuse through with considerable rapidity—the force of diffusion being aided by a second force called capillarity. The result is that, even though the ventilation of a room has been neglected, and no proper outlet has been arranged at the top for drawing off foul gases, diffusion through the ceiling and the walls in the upper part of the room provides so rapid an egress for the hot gases, that they have not time to mingle with the air in the lower portion of the room, while fresh air is being constantly drawn in through every crack and crevice left by the jerry builder.

Gas Lighting as an Aid to Ventilation.—An interesting series of experiments, the results of which are shown in the accompanying table, shows conclusively that, taking an ordinary dwelling room lighted by gas and then the same room lighted by electricity, the air of the lower portion of the room, if one or two people only are present, is as pure with gas lighting as with electric lighting, while if a large number are present, the advantages are enormously in favor of gas—the air with electric lighting becoming rapidly so organically impure as to be positively dangerous to health.

If a number of people are in a room, the organic exhalations as well as the carbon dioxide and water vapor evolved during respiration rise, and, reaching the level of the gas burners, are rapidly swept up to the ceiling by the rush of hot gas from the burner—the flame and heat destroying and charring a large proportion of the germs. The hot air reaches the ceiling and diffuses through the plaster and walls in the upper part of the room, and in doing so the charred organic matter is left behind, filtered off on the surface of the plaster, and rapidly causes that discoloration of the ceiling which is invariably found in a town atmosphere above the gas burner, and which is often wanting with country air. That this is the case is amply verified by the fact that if beams are present at the back of the plaster, diffusion is prevented at these points, and their position is plainly mapped out on the discolored surface.

DISTRIBUTION OF CARBON DIOXIDE IN THE AIR OF A DWELLING ROOM (CAPACITY 2,700 CU. FT.) WITH GAS AND ELECTRIC INCANDESCENT LIGHTING.

GAS LIGHTING.—Two Welsbach "C" burners (on pendant), each consuming 4 cu. ft. of gas per hour, and giving 140 candles.

	Carbon dioxide, parts per 10,000.	Temperature, Deg. F.
Outside air	3.0	61.0
Between joists......	6.0	66 0
Ceiling level.......	44.0	74.7
Breathing level.....	5.0	63.0

ELECTRIC LIGHTING.—Three 16 c. p. incandescent lamps.

	Carbon dioxide, parts per 10,000.	Temperature, Deg. F.
Outside air	3.0	61.0
Between joists.....	4.0	61.5
Ceiling level........	9.0	62.5
Breathing level.....	6.0	61 7

When the room with its occupants was lighted by electric light there was no rapid uprush in this way of the products to the ceiling, and the organic impurities and carbon dioxide leaving at body temperature remained diffused throughout the whole of the atmosphere of the room, causing a far more rapid fouling of the air and injury to health. If such a room were entirely left for its ventilation to diffusion through the walls, it would soon acquire that sour smell which is noticeable in many rooms of the poor, in which, in order to keep in the warmth derived from their own bodies, all ventilation is cut off. This smell is due to the decomposition of organic matter, filtered off during diffusion by the wall surface and undergoing putrefactive decay, giving the offensive odor, the only way to get rid of which is to strip the paper from the walls and lime wash them as well as the ceiling. Then, and then only, does the smell pass away.

When, however, this same diffusion through the ceiling and upper part of the walls of the room takes place in a gas lighted room, this unpleasant human smell, so characteristic of the "tube" railways, is never detected, as the small quantity of sulphur compounds present in the gas (as was shown by researches by Mr. Otto Hehner and Dr. Rideal) is largely absorbed and fixed by the lime and lime salts present, and acts as a disinfectant, destroying all forms of germ life. Here, again, the hygienic superiority of gas is manifest, as in a gas lighted room or hall not only are the germs present in the air, and often of an infectious character, destroyed and burnt up by the flame itself, but also undergo destruction and disinfection from the trace of sulphur dioxide present in the products of combustion—an action which is entirely wanting when the illumination is due to incandescent electric light.

WOOD BENDING

By L. KAY

CONDENSED FROM "WOOD CRAFT."

Wood bending is based on and consists of compression. Wood does not safely stretch a particle; if it does, it breaks. So when wood is bent the difference in the length of the wood on the inside and outside of the bend must be made up for by compression. It is important to remember this fact for several reasons. One is to protect the wood on the outside of the curve from any tendency to stretch which may break it, the other is not only to select the right kind of wood but also to prepare it and get it in such condition that it will compress most readily. It is because a knot will not compress readily that it makes a serious defect in wood intended for bending, and because a knot can not be compressed readily if it is present in that part of the wood which is to be bent it is better to have it on the outside than on the inside, though, of course, it is best not to have it there at all.

Any wood may be bent to a certain extent, but of course some woods bend more readily than others and usually the more tensile strength the wood has the better it is, provided this factor is not interfered with by unusual resistance to compression. An example illustrating this point is hickory, which has great tensile strength and bends well too, but not nearly as easily as it would if it were not so hard and difficult to compress. Elm, which has not the same tensile strength as hickory, but is softer and more easily compressed, will therefore bend more readily than hickory, and where the strength and hardness are sufficient to answer the purpose it makes one of the best woods known for bending purposes. White pine, which is a wood easily compressed, seems to be shy in tensile strength and though it can be and is bent it is not considered for most purposes a good wood to use in this way.

What might be termed the leading woods for bent work are hickory, oak, elm, ash, and there are lots of other woods that are bent and made to bend successfully, among them being gum, mulberry, yellow pine, willow, birch, and a number of others, but the ones named might be considered the leaders in the bent wood industry, and the others enter more as incidentals.

There are some woods that can be bent very readily by simply soaking them in water at ordinary temperature, and many times in the bending of light articles this is all the preparation resorted to. This would indicate that water or moisture is of more importance in the preparation of bending than heat. But it takes water and heat both to make the best combination.

Just what proportion of water and heat are best for preparing wood to be bent is a matter in which people differ somewhat, some going to one extreme and some to another. It doesn't hurt stock and it is really good for it to be immersed in water and the water heated to a boiling point by steam. Another method, and a good one, too, is to put the stock in a box or vat and let it get both the moisture and heat by turning exhaust or wet steam into it. Some people equip a steam box of this kind and use live dry steam. This, while it helps some, is not the best method. If live steam is to be used for the heat, it is best to have the stock immersed in water and heat the water with the steam.

The bending part of the work involves more complications than the boiling and it is rather difficult to give in detail advice as to how best to do the work without knowing beforehand the exact amount of work to be done in each case, the kind of wood to be used, the form it is to be bent into, and the size of the piece to be bent.

One of the many points to watch out for is to protect the back or outside of the bend, to reinforce it, so to speak, while it is being bent, so that it may not give way through a sudden falling of too much strain on one point. The more thoroughly one can protect the back, not only through merely the preliminaries of bending but the entire process, the less loss there is from breakage and the better conformity there will be to the exact

shape desired. If one should take a stick of wood and after it has been boiled properly for bending cut it up into short lengths, it will be found that some sections of it will be compressed more readily than others. It is this difference in compressibility that causes the tendency to irregularity in bending. This tendency leads to kinks and ruptures if the back is not properly reinforced by what are termed straps in the process of bending.

One should be prepared, too, to bend the stock quickly, that is, bend it while it is fresh and hot from the vat; it bends better then than after it gets cool.

VANADIUM STEEL

FROM "THE MINING JOURNAL."

Vanadium steels may be grouped in three classes: (1) Those containing vanadium alone; (2) Those with vanadium and nickel; and (3) vanadium and chromium. The first are usually composed of 0.10 to 0.15 of carbon and 0.15 to 0.25 vanadium. Vanadium has almost as great effect on steel as carbon has, and the effect on the tensile strength of perfectly pure iron, electrolytically produced iron, for example, 54,000 to 60,000 lbs. per sq. in. by addition of a few tenths of vanadium, is certainly very remarkable; and this phenomenon of obtaining so great an effect with so small a cause may be classed as one of the marvels of science. The following are some interesting results obtained by addition of vanadium:

	Tensile Strength in lbs. per sq. in.	Limit of Elasticity in lbs. per sq. in.
Mild steel, low percentage of phosphorus....	60,000	35,000
Mild steel, carbonized with cast iron in graphite crucible	62,000	47,000
Mild steel, with 0.5% of vanadium	94,000	74,000
Mild steel, with 1% of vanadium, not annealed..	138,000	112,000
Mild steel, with 1% of vanadium, not annealed..	102,000	82,000

This 1% vanadium steel is usually employed for objects subjected to vibrations, as it resists the effects of traction admirably.

The second class of vanadium steels is that containing vanadium and nickel. The proportion is usually 0.2 and 0.4% vanadium and 2 to 6% nickel. With these steels a tensile strength of 78,000 to 87,000 lbs. per sq. in. is obtained; elasticity of 55,000 to 70,000 lbs. per sq. in. and elongation varying from 30 to 35%. After tempering, the resistance to tension and limit of elasticity attain 220,000 and 195,000 lbs., and elongation falls from 10 to 8%. Nickel has a peculiar action, as it makes steel hard until 8%, and from 8% to 15% so brittle that one can break it with a hammer; from 15 to 25% extensibility rapidly augments to become almost stationary. Vanadium makes nickel steel more homogeneous, decreases fragility which nickel tends to give steel, though we must add that it is rarely employed with more than 8% of nickel. Such steel, from the fact that nickel gives a very great resistance to impact, is specially suited for piston rods, connecting rods, small shafts, etc.

In the third class of vanadium steels we have vanadium chrome steels, the two best proportions for which are as follows:

Carbon	0.20	0.40%
Chromium	1	1
Vanadium	0.20	0.20

Chromium augments the resistance to impact and tension, but has a tendency to produce a very hard metal, difficult to work hot, and welding can only be operated successfully by electricity, owing to the tendency of chromium to oxidize and form slag. Chromium gives a steel difficult to cut and work cold, and the Carnegie Steel Company could find nothing better to cut this steel plate than a disk revolving at a very great rate of speed. This disk, 6 ft. in diameter, mounted like a circular saw, cuts plates 6 ins. thick; a jet of steam plays continually on the part being cut. Vanadium in the proportion of 0.15 to 0.25% counterbalances the tendency of chromium and facilitates cutting.

*Translated from the "Revue Industrielle"

This steel is particularly suitable for crank shafts, cranks, propeller shafts, locomotive and wagon axles, journals, etc. The following are results of experiments which clearly show the influence of vanadium on chrome steel:

	Tensile strength, in lbs. per sq. in.	Elastic limit, in lbs. per sq. in.	Reduction of area, %	Elongation, %
Manganese carbon steel	56,000	33,000	60	35
The same plus 0.5% chromium	71,000	46,000	61	33
" " 1% "	80,000	51,000	57	30
" " 0.10% vanadium	71,000	60,000	60	31
" " 0.15% "	75,000	64,000	59	26
" " 0.25% "	81,000	71,000	59	24
" " 1% chromium and 0.15% vanadium	101,000	75,000	57	24
" " 1% chromium and 0.25% vanadium	128,000	104,000	46	19
" " 1% chromium and 0.25% vanadium tempered	178,000	148,000	48	16
" " 1% chromium and 0.25% vanadium tempered	203,000	188,000	45	12

From this we may conclude that vanadium steel, which some years ago seemed to have somewhat marvellous effects, making it possible for a tool to work to red heat and cut shavings of hitherto unknown thickness, now enters the category of analyzed phenomena, and that the studies of metallurgists will soon explain how to obtain an alloy to meet a special requirement. It also seems to result from all these figures—roughly approximate—that vanadium can replace nickel, tungsten, molybdenum in steel alloys. However, owing precisely to its infancy, we must add that the question must yet be studied to ascertain how the qualities of the metal withstand the effects of wear and those of time.

ELECTRIC CULTURE OF PLANTS

FROM "THE ELECTRICAL REVIEW," LONDON.

At a recent meeting of the Royal Botanic Society, in London, Mr. B. H. Thwaite read a paper describing the new experimental installation which he has carried out at the Royal Botanic Gardens, Regent's Park. The author divided the early workers on this subject into those who utilized the effects of the arc light on the leaves of plants, and those who applied electrostatic stimuli to the plant and to the roots and stalks, in association with solar light; he then briefly summarized the results of their investigations, and explained the function of chlorophyll in the transformation of inorganic matter into organic products under the influence of light of suitable quality.

"Whilst it may be broadly suggested in the direction of restoring minerals back from their organic state or association to their mineral state, solar electric energy appears to be directed to the conversion of minerals into constituent elements, making up organic compounds necessary for the generation or creation of organic (animal and vegetable) activity summarized by the expression Life."

After further discussing the biological phenomena which characterize plant growth, Mr. Thwaite concludes that "if a near imitation of natural forces is to be secured for the artificial cultivation of plants and independently of the sun or weather, the following agents must be assembled and harnessed for the common object:—

"A.—An ample supply of violet or chemically active rays projected from powerful arc lights.

"B. A supply of electrostatic current for atmospheric and root electrification.

"C. The plant environment of an atmosphere containing moisture and CO_2 in the proportions common to the most fertile countries,

and at temperatures within the limits of 70° F. and 80° F.

"D.—An ideal fertilizing agent.

"E.—An ample supply of water for the roots."

The system of electric culture about to be put to a practical test is designed to produce the condition specified, on a sufficiently large scale. The necessary heat and actinic light, as well as the carbon dioxide, moisture and nitrogen fertilizer in the form of ammonia sulphate, are to be derived from coal; "on the perfection of the combustion of the coal or fuel used depends the entire economy of the system," and this perfection can only be secured by converting the carbon into a gaseous condition.

These conditions are fulfilled by the employment of a suction gas producer and gas engine, whereby perfect combustion is attained simultaneously with the development of power, which is converted into electrical energy. The heat absorbed by the cooling water in the cylinder jacket is utilized for the purpose of heating the air in the glass house by means of circulating pipes, and the heat carried off in the exhaust gases is similarly employed by leading them, after purification, through earthenware junction pipes into the glass house, with outlets at suitable points, so that, at the same time, carbon dioxide, water vapor, oxygen and nitrogen are supplied in a heated condition to the plants, with suitable regulating devices at the points of outlet or discharge.

The author divides the heat energy of the coal as follows: 30% to power production, 30% to jacket water, and 30% to waste gases for heating purposes, the balance of 10% being absorbed in generating the gas and in dissociating the water introduced into the producer into hydrogen and oxygen, which afterwards recombine and pass with the exhaust gases into the glass house as moisture. The gases are desulphurized, both before and after combustion with bog-iron ore. The electrical energy generated is used for feeding the arc lights. An electrostatic machine driven from the gas engine shaft supplies energy which is discharged by points located along the plants, the object being the electrification, not only of the air of the glass house, but of the plants and their roots as well.

The power and heat developed and the proportion of moisture are easily controlled. The arc lights are equipped with special reflector hoods, confining the beam of light within narrow limits of concentration; the open end of the hood is closed in with a water screen, to secure as near an imitation of natural solar effect as possible, and to limit the effect of the ultra-red rays. The water can be colored if desired. The hood is provided with a chimney to carry off the nitrous oxides that may be produced. The arc lights are constantly and almost imperceptibly moved to and fro along the entire length of the glass house by an electrical traveller.

The installation will permit a wide range of experiments to be made, with a view to determining the conditions to secure the maximum degree of acceleration of plant growth with the most perfect quality and augmentation of weight of the products. The power of producing fruit at any period of the year was successfully attained by Sir William Siemens with a comparatively primitive installation, and the triple combination of water-screened arc light, electrostatic stimulus and highly fertilizing atmosphere will, it is hoped, secure still better results.

WHAT IS A CHEMICAL ENGINEER?

FROM THE "CHEMICAL ENGINEER."

What is a Chemical Engineer? The Standard Dictionary defines an engineer as "a person who manages an enterprise." The civil engineer is hence one who manages a civil enterprise, such as the erection of a bridge, the building of a road or the construction of a reservoir; the mechanical engineer is one who manages a mechanical enterprise, such as the building of an engine, its design or even its operation; the mining engineer manages mining enterprises, and the electrical engineer electrical enterprises, etc. The logi-

cal step from this is that the chemical engineer is one who manages, hence designs, operates or directs chemical enterprises, or as much of any enterprise as requires for its successful conclusion the application of chemical principles.

Webster defines engineering as "originally the art of managing engines, in its modern and extended sense the art and science by which the mechanical properties of matter are made useful to man in structures and machines." It is very easily to pass from this definition to that of chemical engineering; i. e., as the science by which the chemical properties of matter are made useful to man in products and appliances.

The words engine, engineer and also ingenium, meaning natural capacity, all come from the Greek verb meaning to produce or create, hence the engineer is merely one who produces or creates military, civil, mechanical, mining or chemical products or appliances. The root of the word certainly does not lead one to the conclusion that it is to be applied only in a mechanical sense.

Let us draw a parallel between the mechanical and chemical engineer as an aid to better understanding. The mechanical engineer, for example, defines the physical proportion of a casting, length, breadth and thickness, designing the dimensions of its various parts to meet the requirements to which it is to be put. The chemical engineer on the other hand defines the chemical composition of the casting and specifies the percentages of phosphorus, sulphur, silicon, carbon, etc., it shall contain. In a steel rail the mechanical engineer gives the dimensions of the flange, the head and the web, but it is the chemical engineer who gives the steel that composition which secures safety to the traveling public. If the rail is not properly proportioned physically it will fail, and likewise if the chemical proportions are incorrect.

MANUFACTURE OF BOILER TUBES*

By F. N. SPELLER

All processes for recovering iron from its ore have the first operation in common in that the blast furnace is used to obtain a crude iron carrying about 5.6% of foreign matter, which is afterwards removed by further refining until we have commercial iron or steel. The name by which the finished product is known depends more upon the process by which the refining is completed, rather than the degree of refinement.

For the manufacture of welded tubes, we were limited to charcoal iron until the art of making weld steel was sufficiently developed. At the present this steel gives better results in welding than wrought iron, and by a special process of mechanical working which we apply at, or near a welding heat the texture is made compact and fine and the life of the tubes increased. The principal characteristic of charcoal iron, not possessed by steel, is the presence of 1 to 2% of cinder. This cinder acts as a flux to carry away impurities in the raw iron, but a certain amount remains entangled in the ball of refined iron when it is withdrawn from the forge. Subsequent hammering only partially removes this cinder. Microscopic photographs of cross sections of iron and steel plates show the distribution of the cinder in wrought iron and the comparative unbroken granular section of the steel. It will be observed that there is no relation between the grains of iron and the cinder and that the iron is just as granular as the steel. It is the presence of this cinder that gives iron its fibrous appearance when broken, however the fibres are evidently not iron, but strings of cinder which have no strength in themselves and only serve to break up what would otherwise be a continuous and uniform granular structure. In other words, weld steel may be considered as highly refined iron freed from cinder. Charcoal and other wrought irons are finished in a pasty state and retain a certain amount of cinder imprisoned in the mass, while soft steel is finished in a molten condition, which permits the cinder, in virtue of its lightness, to rise and float on top of the molten metal.

*From a paper recently read before the Richmond Railway Club

An erroneous idea has been spread abroad that the grains of iron are "enveloped" in cinder and thus protected from corrosion. The fallacy of this argument is plain when we see the true relation of the strings and plates of cinder to the grains of iron. The fact is that the iron "envelopes" the cinder.

Charcoal iron is naturally less uniform than steel, first, on account of the irregular quality of the pig iron used; second, the small quantity made in one heat, and third, on account of the large factor of personal attention and skill required on the part of operator. It is becoming more and more difficult to secure sufficient high class men for this work, for although wages have been advanced materially, men of the necessary intelligence can usually do better at other work of a less strenuous character.

Lap weld boiler tubes are made by first scarfing the edges of the plate and then drawing through a die so shaped as to lap the edges over about ⅜ of an inch. The skelp is next pushed into a welding furnace heated to the required temperature and passed through a set of rolls. Between these rolls a ball is held in position by means of a stout rod over which the tube passes on leaving the furnace. Boiler tubes are given two heatings and two passes through these rolls at a welding heat by which the lapped surfaces are firmly pressed together and united. The tube is finished by passing through a similar set of rolls slightly smaller in diameter and without a ball inside, and then straightened in cross rolls and slowly cooled. The ends which have to stand working are annealed at a bright orange to reduce the grain caused by the welding heat, thereby giving a greater margin of safety in expanding and rolling. After welding and cooling, the rough ends cut off the tubes are crushed down flat with the weld on the side. If no sign of opening of the seam appears, the tube passes on to the inspectors, and if free from surface defects, is subjected to the specified hydraulic tests, usually 600 pounds per square inch. Samples are taken from time to time through the day on which standard M. M. tests are made. If the tubes stand this inspection and testing successfully they are marked with the tester's number, length, etc., and are ready for shipment.

Charcoal iron cannot be used in the manufacture of seamless tubes, as it is not strong enough or sufficiently uniform. A special grade of selected open hearth steel is made for this purpose, containing about 0.17% carbon and 99.3% iron. The carbon is low enough to permit of welding without difficulty, although the grade of steel made for lap welding which contains considerably less than this amount of carbon, is naturally somewhat easier to weld. The steel is first rolled into round bars about 2¾ to 3 inches in diameter x 30 to 40 inches long. These are heated and pierced in a mill to a rough tube 2¾ to 3 inches in diameter x 5-16 inch wall x 7 to 8 feet long. The disks of the piercing machine lie in parallel planes and are mounted on the ends of shafts, the axial lines of which are also parallel and lie in the same horizontal plane. The disks revolve in the same direction, so that the round billet passed between them in contact with their opposing surfaces has imparted to it a rotary movement, and if the blank is passed between the disks, either slightly above or below the plane of their axes, it has imparted to it a longitudinal movement also. The next operation after reheating, consists in passing the pierced piece successively through rolls somewhat similar to those used in lap welding, with a mandrel to maintain the inside diameter. The ends of the partially finished tubes are now "pointed" or hammered down preparatory to cold drawing. After each draw through the die the tube is annealed and pickled clean, the final operation being a thorough annealing. The tests applied to seamless tubes are the same as those described for welded tubes.

TECHNICAL MISCELLANY

COLOR PHOTOGRAPHY

years of experience by the sci- nventors of two continents, one ewards of modern endeavor—the graph—seems about to be rea- te and Louis Lumierè of Paris ounced the perfection of a pro- this result can be attained with ree of simplicity than had previ- ought possible. They have also further the puzzling problem of he pictures on white paper in the d on the colored negatives.

m of printing from color nega- r has not been solved to the sat- ientists, but the latest inventions blem to a point where the results e and surprising. They simplify f color photography to such an most any photographer may make lves. Copies of paintings and art be preserved for years in all the the original colors. Americans e moving pictures of transient ance sunset, the inauguration of or an afternoon on Broadway— ne, fully colored, were passing The fact that the latest inven- photography enable artists and to preserve their models perma- n color, is by no means the least the recent results.

on of Auguste and Louis Lumierè, s expert photographers in Paris, lf-coloring or autochrome plates, lly sensitive to all rays of all col- adapted to any ordinary camera. ave taken photographs know, the es of colors in a scene are de- transferred to a plate. Red be- blue white, and so on. The un- ciple of color photography is to se colors in their relative values, icture on the plate shall be rela- ne as the image in the eye. Heretofore this effect has been obtained by "filtering" the picture through screens of colored glass inserted in the camera in front of the plate. The process was elaborate, and success depended largely on the scientific expertness of the photographer. The Lumierè invention consists in placing a layer of colored grains in front of the sensitive material on the plate, thus making color photography as simple, relatively, as taking an ordinary picture. The grains not of the color of the object photographed are masked by a blackening of the sensitive material, and the grains remaining visible, therefore, represent the color of the object.

The grains are made of potato flour ground up until the particles are about 4-1000th of an inch in diameter. These are colored green, violet and orange, and are thoroughly mixed and laid on the plate. Then the minute spaces between the grains are filled with an exceedingly fine charcoal dust.

The green, violet and orange thus placed on the plate are the complementary shades of the primary colors, which are red, yellow and orange. In the negative the red of nature appears as green, the yellow as violet, and the blue as orange. The grains are transparent, permitting the light to pass through them to the sensitive plate, but modifying it by their color, and preserving the relative values of the tints in the original scene.

It is in the development of the plates, however, that the Lumierè process is considered most interesting by scientists. The novelty of their invention is their method of converting the negative into a positive, and obtaining a single colored photograph on glass. They do not destroy the silver bromide on the plate, as is usually the case, but place the plate in a bath, destroy the negative, and develop the rest of the silver salt into a positive.

The Lumierè process is best understood by following it from the moment the rays of light

pass into the camera until the colored photograph is shown on the finished plate. The example selected for the French accounts of the invention is the flag of that nation, in blue, white, and red.

As the rays from the blue part of the flag pass to the plate, they are absorbed by the orange grains on the film, while the green and violet rays permit the light to act on the sensitive medium. In developing, the bromide of silver will blacken under the green and violet grains, which the medium will mask, and leave transparent only the orange grains. The rays from the white in the flag will not be absorbed, and will blacken the sensitive layer under all the colored grains. The rays from the red will be absorbed by the green grains, the latter remaining transparent. These rays will affect the bromide of silver, under the violet and orange grains, which will be hidden, leaving the green visible. The plate then gives the complementary colors of the original, and the flag seems to be three strips of orange, black, and green, respectively.

The reduced silver is dissolved by the permanganate of potash process, and then the negative is transformed to a positive, in the sunlight, thus reproducing the colors of the original with absolute accuracy.

The reduced bromide of silver in the section of orange, which obscures the violet and green grains, has been dissolved under the action of the permanganate of silver, and, in the second development, the bromide of silver not reduced blackens under the orange grains. These being masked, and the violet-green grains now being exposed, the two combined give the impression of blue.

The white will be formed by all the reduced silver being dissolved in the black zone, thus reproducing the three primary elements—orange, green and violet.

The third, or red, section of the flag is represented at this stage in the development by what seems to be a block of green. The green grains are masked by the second development, and the illusion of red is produced by the mixture of the violet and orange grains.

American experimenters in color photography, while admitting the novelty in this process of development, question the originality of the Lumierè invention, and are especially sceptical regarding the claim that the French photographers can print from these colored negatives photographs on paper, which will have even the approximate brilliancy of the original plates.

An expert in this city, to whom the theory was submitted last week, said that color photography had not yet been developed to the point where colored negatives could be reproduced on paper with satisfactory results by photographic processes.

Even the best paper, he explained, only contains from 50 to 75 per cent. of the full illuminating qualities of light. While transferring the colors to this surface, each must lose a large part of its original value, the white being a combination of the rays. The result, he added, was a loss of color so material that it was next to impossible to reproduce the brilliant tints of the original.—"New York Times."

LIGHTNING AND THE POSSIBILITIES OF ITS UTILIZATION

Having harnessed the streams and even converted wave force into electricity, the modern physical scientists have undertaken to make a more careful study of the phenomena of lightning in the clouds with a view to possible utilization for industrial purposes. To the electrician the play of lightning seems like a great waste of energy. An electrical storm possesses enough potential energy to drive a good many factory wheels. A lightning flash several miles long casts athwart the earth an illumination so great and intense that our highest developed electrical lamps seem insignificant in comparison.

Recently a brilliant electric flash on a cloudy day has been estimated to give light equal to one-foot candle power, and if one watt is allowed per candle foot a flash of lightning a space of two miles would represent an expended energy of some 10,000 kilowatt seconds. Imagine an artificial lamp produced by man's ingenuity capable of spreading an illumination like this through space! The flash through space illuminates two miles square of earth, which would require many hundred thousand incandescent lamps to equal.

But that we have many misconceptions about lightning is apparent from recent investigations. A lightning flash frequently extends over several miles of space. A single flash of 10,000 volts an inch would thus require a potential difference of about 1,200,-

0 volts for the entire length of two
Such a voltage in the clouds is almost
ivable. It is not in accord with all of
ias of the nature of electricity.
iould, so far as we can conceive, annihi-
iole communities and destroy all human
thin a radius of many miles of the light-
ash. Aside from the question of killing
the voltage, it would mean a frightful
of nitric acid. Far less than a fraction
s enormous voltage would electrically
down the air and produce ozone and
acid. That is, the molecules of the air
sociated and recombined. What would
unfortunate condition of the inhabitants
district where a lightning flash caused
ge of nitric acid is something not pleas-
contemplate.

such does not happen. Ever since man
habited the earth violent thunderstorms
ectrical flashes have broken the monot-
summer's heat, and so far as the rec-
iow no remarkable visitation of unusual
ties has resulted therefrom. Yet the
nena of the lightning flash have puzzled
sts. They could not understand why
and nitric acid were not formed in enor-
quantities by even an ordinary flash.

the secret of it now appears to be that
es are not capable of recording accu-
this peculiar phenomenon of the heav-
t is all an optical illusion, this watching
of lightning. It is not one violent dis-
, but a series. A flash two or more
in length is made up of thirty to fifty
ive discharges, occurring so rapidly that
ppearance seems almost simultaneous to
e. An impression on the human eye per-
or only 0.1 second, and it cannot meas-
ything less than this. Consequently if a
of lightning is only one one-thousandth
econd in duration we cannot distinguish
a one persisting only 0.1 second. Herein
re the secret of our misconception comes

camera measures light much more ac-
y and sensitively than our naked eyes.
photographs of lightning flashes have
taken which show that successive dis-
s make up a flash which is a mile or
n length. In other words, there is rarely
ngle flash, but a series of disruptions.
ating cameras as many as forty succes-
ashes have been recorded in a two-mile
rge, the whole lasting less than six-
of a second.

being the case, a lightning flash of several miles in length may occur without creating any great potential difference in the ends. The action of a discharge is much like a landslide down a steep sand hill. A slight movement of a pebble may start several other particles downward until the movement becomes general, and a landslide follows. A slight discharge of electricity from a cloud is followed by another and another until the total let loose is enormous. But the total voltage discharged at any one time is relatively small, possibly 50,000 volts a foot at the moment of discharge, with an average potential difference between different points of the cloud of 50,000,000 volts.

Sensitive recording instruments have begun to measure the lightning flashes, and in this way our knowledge concerning the electrical discharges of the clouds is being made more accurate. For instance, it is pretty well known now that the duration of the discharge is about one-five-hundred-thousandth of a second, a duration that is utterly incomprehensible to the human mind. The average energy of the discharge at 10,000 kilowatt seconds would be equal to 7,000,000 foot-pounds expressed in simpler language.

If we accept this potential energy of a flash of lightning, constituted as it is of a series of almost simultaneous discharges, we might translate it into even plainer language by showing what it could do if it was directed toward some useful work. In electrical science we speak of the kilowatt hour instead of the kilowatt second. We know approximately what can be accomplished by a kilowatt hour when electricity is harnessed to perform different work. On this basis of computation the potential energy of our flash of lightning in the clouds could perform some marvelous feats in the industrial world.

Approximately it could saw 830 feet of deal timber if harnessed to a mill to drive a modern circular saw, or it could be used to sharpen 14,000 knives if used for driving a grindstone. It has sufficient potential energy to carry you some nine miles in an electrical automobile if properly harnessed and used for this purpose. It could pump 100 gallons of water to a height of twenty-five feet something like three times.

Of course, there is no limit to what the flash of lightning could do if properly harnessed and its potential energy stored so that it could be used for driving machinery. Its usefulness would be limited only by the machinery invented for doing man's work, and this, as we all know, is sufficiently varied to include al-

most every known labor. When Benjamin Franklin first tried to bottle up the lightning of the clouds he probably had no adequate knowledge of its potential energy, and even until very recently it was largely guesswork as to what force or energy a single electrical discharge on the clouds represented.

If the day should ever come when such electrical discharges could be harnessed and used to do work for man, a summer thunderstorm would become a commercial possibility that would attract the greedy. It would be a scramble then to gather the lightning of every storm before a rival could get ahead of you. Legislation might then have to be enacted to protect us from having our chief summer displays of heavenly fireworks destroyed, much as we have had to pass laws to prevent the destruction of Niagara by the electrical power companies.—"New York Times."

RADIUM AND THE TRANSMUTATION OF THE ELEMENTS

Ten years ago an intrepid Polish woman and her brilliant Parisian husband, Prof. Curie, announced a discovery that startled a world accustomed to wonders. Radium is even more remarkable today than phosphorus was to those seventeenth century alchemists. It has caused such astonishment that we have so far been unable to coin an adjective sufficiently descriptive. It glows in the dark; it is always hotter than its surroundings; it charges bodies electrically when they are near; it discharges bodies already charged with electricity, and it constantly gives off a gas called an "emanation" by Rutherford, its discoverer. This emanation goes through a number of changes, eventually forming helium.

Radium is an element, according to agreement, for it has a definite atomic weight and a characteristic spectrum. So is helium. Radium is transmuted into helium and we have apparently the dream of the alchemist realized. This has been the attitude of belief on the part of the most generous contributors to our knowledge of these unique substances. The opposite point of view, however, has been held by Lord Kelvin in England and by the writer in this country, because if radium be an element, it should not break up into anything simpler than itself. These opponents [illegible] changing our definition of an element, or even accepting radium as a [illegible] element, [illegible]

[illegible] experimental evidence [illegible] transmutation of the elements.

Rutherford in his studies learned that the emanation from radium during its degradation through several steps to helium gives out an enormous amount of energy, vastly greater than in any process previously known to man. A comparative idea of this is had from calculations that have been made. A pound of the purest coal when burned in pure oxygen produces enough energy to lift its weight two thousand miles, or say from New York to Venezuela. A pound of hydrogen burned under similar conditions, a most violent chemical reaction, generates heat enough to lift its weight eight thousand miles, or say to Honolulu. A similar amount of radium, without any burning, produces enough energy to lift itself to the orbit of Neptune, or thirty times the distance from the earth to the sun. The decomposition of the emanation produces by far a greater portion of this energy. Surely such forces operating upon matter should cause events to come to pass with which man is unfamiliar. Indeed, he can scarcely foretell them, although Faraday once said that "most molecules—probably all—are wrecked by intense heat, or in other words by intense vibratory motion, and many are wrecked by a very impure heat of the proper quality." Herschel, in fact, as a result of his study of the temperature of the sun, remarked that the atom has the stamp of a manufactured article.

When the emanation is placed in a dry vessel it breaks down into helium, as Ramsay, Soddy and others have proved. Ramsay has also shown that when the emanation breaks down in the presence of water, neon, one of [illegible] elements found by him in the [illegible]. When the emanation is allowed to break down in a solution of blue vitriol or copper sulphate, argon is the lazy gas produced. One of these is five and the other ten times as heavy as helium. We

ld expect the argon and neon thus pro-
l to continue breaking down until helium tained. We have not been informed on point as yet, but we do know that these ents obtained from other sources have not t been observed in such a temporary state. e most remarkable part of Ramsay's ob- tion, however, was concerned with the l left behind. When the copper was re- d from the solution, lithium was detected e residue by means of the spectroscope. was not the case when copper was re- d from a similar solution before treat- with the emanation. Gold, silver, cop- and lithium are members of one of the lled chemical families. Lithium is the ber with the least atomic weight, being inth that of copper. Evidently, there- the powerful emanation had brought a idation of the copper, the element copper been transmuted into the element lithium

justice to Ramsay it should be stated he actually makes no real claim to what generally been understood as transmuta- Especially does he maintain that his has no connection with the current ac- tion of the term, namely, the conversion ver into gold. He calls it degeneration of element into another. Now, if silver is a little more than half as heavy as gold, quently such a conversion would be a re- of his claims. It may be well to remind reader that Emmens in this country made to this reverse process, and the claims very widely heralded. The basis of Em-'s claims were as follows: Silver is 10.5 gold 19.3 times as heavy as equal vol- of water. If by some mechanical device ent pressure could be exerted upon a definite volume of silver, so that it occupied one-half of its former volume then we should have silver 19.3 times as heavy as an equal volume of water, the same as gold. This was called "argentaurum," a word coined from the Latin names for silver (argentum) and gold (aurum.) Although it was claimed that the United States mint accepted this "argentaurum" for gold at full price, we are not aware that it has played any part in changing the standard of values in commerce.

Can this emanation be Bacon's "philosopher's stone" reversed? If so, is there any way of taking the fairly abundant elements of comparatively low atomic weights, like calcium (from lime), aluminum (from clay), or copper even, and so saturate it with energy that it acquires properties like radium or platinum or gold?

Most writers on radium think such an accumulation of energy as shall be sufficient to build up that substance impossible, at least with our known agencies. The author, however, is not so sure of it from certain experiments not yet completed. A hundred years ago the telephone, with its present perfection, was a wild dream. Twenty-five years ago the communication of continent with continent was beyond comprehension. Fifteen years ago if any one had said we should soon be able to see the bony structure of the body through its fleshy covering and envelope of clothing, he would have been thought a fit and proper subject for an asylum. Yet, now we have the X-rays. Some wild dreams have come true. That, however, is no reason for assuming that all the pictures a fertile imagination may lay out are to become verities.--Charles Baskerville, Ph.D., in the "New York Times."

SCIENCE IN BURGLARY

nsul Thomas H. Norton, writing in the Consular Reports from Chemnitz, says the confidence of German manufacturers es in the resistance of their wares against ary safe-blowing operations has been r shaken by the recent achievements of gle unaided robber in Dresden and other The details of his last operation are as ws:

In a hotel a room was secured, which was situated immediately above the office of a money changer. At night a hole was pierced in the ceiling of this office. By the use of a drill and saw a circular piece of the flooring was easily raised. Beneath lay a thick layer of cement. A small orifice was made in this and an umbrella shoved down into the space below. The umbrella was attached firmly

from above, and when opened received without noise all the fragments of cement which were dislodged as the hole was enlarged so as to allow of the easy passage of a person. By means of a rope ladder the descent was readily made into the office below. Curtains were drawn and with heavy blankets a tent was constructed around the safe so thick that no ray of light could pass through. Next the robber brought down two cylinders of compressed oxygen and an acetylene generator charged with calcium carbide and water. With these he was able to produce a blowpipe flame of such intensity that steel fuses in it like lead in an ordinary gas jet. It required but a brief space of time to melt away so much of the door that all the contents of the safe were accessible. They were carried to the room above. At an early hour the robber left his lodgings and disappeared without trace.

It is evident from this experience that the builders of safes must provide for new contingencies in their constructions. The simple, light, acetylene generators, now in widespread use, and the equally simple oxygen generators, charged with water and sodium peroxide, or the heavier cylinders of compressed oxygen, place at the service of the intelligent crook the possibilities of opening the strongest safes in existence rapidly and noiselessly, provided the operator can be screened from observation.

Some large safes are so disposed that they are under frequent observation by watchmen looking through windows. Usually this observation is confined to the doors of bank vaults or the like, although in the case of globular safes it practically extends to all exposed sides. In the greater majority of cases existing safes would offer next to no difficulty to a skilful cracksman if able to work without being seen. It is evident that owners will be forced henceforth to adopt such measures as will reduce to a minimum all possibilities of access to free-standing, movable safes or the hidden sides of safes, embedded in cement or masonry.

Manufacturers of safes will, on the contrary, be impelled to fight the scientific burglar with his own weapons. In somewhat the same fashion by which time locks prevent the opening of the lock of a safe during certain hours it will be comparatively easy to introduce into safe construction chemico-mechanical devices which, during a limited time, would render it either fatal or physically impossible to remain in the vicinity of a safe or vault were the walls or door tampered with to such an extent as to allow access to the interior. By the use of a very simple form of apparatus containing potassium cyanide and sulphuric acid a robber would expose himself to the deadly fumes of prussic acid.

Less dangerous, through possibilities of accident to those regularly using a safe, would be the employment of substances crippling a safe blower or forcing him to an instantaneous retreat. The volatilization of a few drops of ethyl-dichlor-acetate would cause such profuse and persistent weeping that one in the immediate neighborhood would be temporarily blinded if he persisted in remaining. The breaking of a tube of liquid ammonia would render immediate withdrawal imperative under peril of suffocation. Several similar compounds are at the service of constructors. Eventually the daring burglar with sufficient scientific training might venture to face the unknown dangers of a safe well provided with more or less effective neutralizing agents for the concealed possibilities of defence; but certainly for some time, at slight expense, effective protection can be devised against the attack of the scientific cracksman with his portable oxy-acetylene blowpipe.

OTES ON ENGINEERING AND APPLIED SCIENCE FROM ALL SOURCES

ctrolytic Pickling of Steel.—The hardest can be removed from iron and steel in minutes, by employing an electrolytic ss where the metal is the cathode. In case the acid solution is at 60° C. and specific gravity of 1.75. The current ty of the cathode is 1.4 amp. per sq. in.

n Under Stress and Electrolytic Action.— iron is subjected simultaneously to and electrolytic action, there is no e in the e. m. f. of electrolysis resulting changes in stress below the elastic limit. the elastic limit the voltage required lectrolytic action rises, but after rupture . m. f. immediately falls to normal.

bber Belting.—According to Wm. O. er, in "The Engineer" (Chicago), good, alendered rubber belting made with 30- ack and new (not reclaimed vulcanized) r has a thickness of about 1-16 in. per The safe working strain for a belt 1 in. dth ranges from 15 lbs. per ply for a 3- elt up to 18 lbs. for an 8-ply belt.

t of a 500-HP. Diesel Oil Engine.— made at the works of Sulzer Bros., Win- ır, on an engine of this capacity, showed sumption of 0.43 lb. of crude oil per horse-power at full load, 0.462 lb. at oad, and 0.544 lb. at quarter load. The ed had a calorific value of 18,823 B. T. r lb., making the actual thermal efficien- 115 at full load.

ene is the name given to an alloy, re- brought out in Germany, which is com- of two parts of aluminum and one part nc. It is said to equal cast iron in gth, but is much more elastic. Alzene perior because it does not rust as easily s iron, and it takes a high polish. Be- being very strong, this new alloy is capa- f filling out the most delicate lines and s of forms in casting.

Detection of Sewer Gas.—The "American Analyst" gives the following test for the detection in an apartment of sewer gas: Saturate unglazed paper with a solution of one troy ounce of pure acetate of lead in eight fluid ounces of rain water; let it partially dry, then expose in the room suspected of containing sewer gas. The presence of gas in any considerable quantity soon blackens the test paper.

To Purify Drinking Water.—M. Lambert proposes, in the "British and Colonial Druggist," to add 6 cgms. of permanganate of potash to each liter. This should be left ten minutes, after which 10 cgms. of manganous sulphate should be added. This precipitates all germs and impurities to the bottom of the vessel. Carefully decanted this will give "water not containing a single microbe, limpid, colorless, of pleasant taste, and even richer in oxygen than ordinary water."

Heating with Exhaust Steam.—According to Mr. F. W. Ballard, in a paper recently read by him before the Ohio Society of Mechanical, Electrical and Steam Engineers, about 250 B.T.U. are radiated per hour per square foot of radiation, when a full head of exhaust steam is maintained upon the radiators. One pound of exhaust steam will supply about 3 sq. ft. of radiation. Assuming that the engines in the power plant consume 30 lbs. of steam per HP.-hour, then 1 HP. capacity in the power plant will furnish exhaust steam enough to heat 450 sq. ft. of offices, 600 sq. ft. in the factory, or 900 sq. ft. in the warehouse.

Lead Wool, or shredded lead is now extensively used for jointing lengths of pipes in place of the cumbersome and wasteful method of pouring molten lead inside the joint and calking after it has cooled. Lead wool is furnished by the United Lead Co. in strands, which are forced into the joint after the yarn has been put into place. Each layer is firmly

calked as it is put in, the result being a tight, solid joint. Joints can be made under water or in the rain, and the pipes may lie in any position whatever. Such work is evidently impossible with the molten lead method, for lead cannot be poured up-hill nor in the presence of moisture.

Atomic Weight of Radium.—Madame Curié has made new researches to determine the atomic weight of radium. The method employed consists in quantitatively analyzing, in form of silver chloride, the chlorine contained in a known weight of anhydrous radium chloride. Acording to the old experiments, confirmed by new observations, the recently-prepared radium chloride loses its water of crystallization when heated above 100° C., and attains a perfectly constant weight after half an hour at 150° C. The conclusion is that the atomic weight of radium is 226.2 (Ag = 107.8; Cl = 35.4) with a probable error of less than ½ unit. If we adopt the values Ag = 107.93, Cl = 35.45, we obtain Ra = 226.4.—"Mining Journal," London.

Specific Heat of Fire Brick at High Temperatures.—A knowledge of the specific heat of fire brick, especially at high temperatures, is necessary in many calculations. Messrs. C. F. Howe and C. B. Harrington have recently reported results of their investigations on this subject in the "Journal of the Worcester Polytechnic Institute," from which we take the following:

Temperature Range, degs. C.	Specific Heat.
0.... 100	0.221
200.... 300	0.233
400.... 500	0.245
600.... 700	0.257
800.... 900	0.268
1,000....1,100	0.281

Increasing Locomotive Tractive Power.—A novel scheme for this purpose devised by Mr. G. A. Bothwell, of Owen Sound, Ont., consists in providing a second set of driving wheels of much smaller diameter than the regular drivers, to give the requisite greater tractive effort and a system of gearing for utilizing the adhesion of the engine truck and also of the tender, if desired. When the small drivers are on the rail the large ones **are lifted** clear of it and vice versa. **The purpose of the scheme is a locomotive of maximum hauling capacity with minimum weight; that is, to provide within locomotives of the usual types means for taking over ruling grades trains which they would otherwise be unable to haul, or for which helper service would be needed.**

Waterproof Concrete.—According to Mr. R. H. Gaines, in an article in "Engineering News," watertight concrete may be obtained in three ways:

(1) By replacing the mixing water with a dilute solution of a suitable electrolyte or salt. The concentration of the solution need not exceed 2% in strength. A 1% solution is believed to be sufficient, since greater concentrations are not further ionized.

(2) By replacing from 5 to 10% of the cement with an equal quantity of dried and finely ground colloidal clay, intimately mixed with the cement.

(3) By the use of both the solution of the electrolyte and the clay.

Experiments show that these substitutions not only give a watertight product, but, at the end of a given period, add greatly to the strength.

Specific Gravity of Portland Cement.—The specific gravity **test is of no value whatever** in detecting **underburning, as underburned** cement will **show a specific gravity much higher** than that set by **the standard specifications.** Underburned **cement is readily and promptly** detected by **the soundness tests and no others** are needed for **this purpose.**

The requirements **for specific gravity should** be omitted from **the standard specifications.** Or at least **the clause which infers that** low specific **gravity is caused by underburning** and adulteration **should be omitted and** in its place one stating **that low specific gravity** may but **does not necessarily imply adulteration,** as it **is in most cases due to seasoning** of the cement **or storage of the clinker** before grinding, both **of which are beneficial** to the product.—**Richard K. Meade and Lester** C. Hawk, in a paper **read at the Atlantic City** meeting of the American **Society for Testing** Materials.

Saline Solutions For Dusty Roads.—In a recent number of the "Bulletin **de la Société In**dustrielle de Rouen" **Messrs. Houzan and Le**roy call attention to the **use of solutions of** the chlorides of sodium, **calcium, and magnesium** with the object **of laying the dust produced** by automobiles. The **two latter chlorides**

specially advantageous owing to the de-
scent nature of these salts. Calcium ide was first tried for this purpose as ago as 1828. A solution of this salt hav- specific gravity of 10-15 degs. Beaumé is table strength for sprinkling, and is ap- to the roads in the same way as water. salt has the further advantage of being and non-poisonous, having in fact cer- disinfecting properties; it is not corrosive ordinary metals, and may therefore be d in metallic vessels, but it attacks the inted surfaces of copper, nickel and brass. kling with tar or oil is more expensive with calcium chloride, and this salt does ive rise to dark mud, rendering the roads ery.—"Times (London) Engineering Sup- ent."

ength of Shafting.—Considerable discus- has recently taken place in the columns Engineering" (London) in regard to the of the bending moment which is equiv- to the combined effect of the cross-bend- moment and the twisting moment. There three formulas expressing this value; ely, Rankine's, in which M. ½ M + ½ (+ T²); the French, in which M. ⅜ M + (M₂ + T²); and Guests's in which M. = √ T²). Of these, the latter gives the greatest , and is generally believed to be the accurate. The difference in these form- is due to the difference in belief as to the t of the second skin stress, that is, the perpendicular to the maximum stress. tine argued, probably without experi- al data upon which to base his theory, this second stress had no effect. The ch formula is derived from a particular cular theory, to the effect that a material s when a definite extensional strain is ed. Guest's law, borne out by tests made is country by Prof. E. L. Hancock, makes rue shearing strength the quantity to be in determining the yielding of a ductile rial.

New Road Dust Preventive.—Consul T. Norton, writing from Chemnitz, says that xon firm has introduced a new road-bind- composition called "Apokonin," which has tried on the macadamized streets of Leip- and other places with much success. The rial is thus described:

is a mixture of the heavier residual oils ned in the distillation of coal tar with high-boiling hydrocarbons. The method of mixing apparently involves a certain degree of chemical combination, in which phenol and similar constituents play a role. The manu- factured material is prepared for use by heat- ing in iron caldrons, identical with those used for asphalt, to temperatures ranging from 212° to 248° F. (100° to 120° C.). It is then sprayed evenly over the surface of a roadway with a special form of apparatus, and under such high pressure that the fluid mass pene- trates to a certain distance into the upper layer of dust or dirt. The result is the forma- tion of a compact lustrous black coating, which meets the demands of heavy traffic and is not disintegrated into dust particles. A marked advantage of the new process over the methods hitherto employed for the same purpose, and based upon the use of ordinary tar, is the total absence of odor after the ap- plication.—"Consular and Trade Reports."

Sodium Transmission Lines.—The use of sodium for overhead transmission is attract- ing the attention of electricians. It is said to be cheap and a good conductor of electric- ity, but as its marked affinity with oxygen causes it to ignite when placed in contact with water, its employment in the form of a con- ductor would be limited, probably to overhead transmission lines or feeders for railway work. The general process of constructing sodium conductors is to take standard wrought-iron pipes and heat them to a point well above the melting temperature of sodium. The sodium is then melted in special kettles and is run into the pipes, solidifying when cool. There is said to be no marked depreciation of either the sodium or the pipe if the latter be prop- erly protected by a coat of weather-proof paint.

For the same conductivity the price of the complete sodium conductor is much below that of copper cables, being in small sizes not more than 50% and in large sizes not more than 20% of the cost of copper. For instance, a half-inch wrought-iron pipe filled with sodium has a capacity of 109 amperes, and costs about 3½ cents per foot, against 8½ cents for a copper line of the same capacity. A 6-inch sodium conductor would carry 8,130 amperes, the cost of the line being about $1.40 per lin- ear foot, as compared with $6.30 per linear foot for copper. These figures were estimated on the basis of 7½ cents per pound for sodium and 16 cents per pound for copper.—"Daily Consular and Trade Reports."

Falling-Water Air Compression.—There is one method of making compressed air which is simple, efficient, practical and isothermal, and, in comparison with a reciprocating compressor, possesses almost twice the efficiency with a cost of only a fraction of that machine. The process referred to is known as the water-compression system and is in active and efficient operation at Magog, Quebec; Norwich, Conn., and a number of other places. These plants produce compressed air in large quantities very efficiently with a minimum cost of operation and a minimum cost of installation. There are, however, patent rights involved in the process which may be responsible for its lack of development in other fields.

A description of the plant will explain its operation. Water is carried in a large pipe on a slight slope to the edge of a vertical pipe of any desired length. It is then allowed to fall down this pipe. An annular hollow ring with a large number of fine points on the lower side is immersed in the water at its entrance in the hole and this is connected with a pipe to the outside air.

The water flowing by these small holes, which are often extended into projecting hollow needles for increased efficiency, entangles and carries with it small bubbles of air caught at the points of these needles. Rushing down the pipe it gradually compresses the bubbles and when the water is suddenly turned at the bottom into a tank or air reservoir, it comes to rest and the bubbles rise to the surface, under pressure. A pipe carries the water from this reservoir [illegible]

[illegible] amount depending simply on the quantity of water rushing through the penstock and its speed.

The efficiency of a plant of this kind ranges from 75 to 83% of the theoretically possible efficiency obtainable from the water.—J. H. Hart, in "The Engineering and Mining Journal."

A New Method of Galvanizing.—If two metals in contact are both readily decomposed by the same agency, and if when in contact they are exposed to that agency, the metal which stands lower down the scale of electrical conductivity will be decomposed in preference to the other. This is the reason for the efficiency of a zinc coating for iron and steel articles and is distinct from the protection afforded by the covering as such.

"Sherardizing," a dry process of galvanizing, owes its existence to the peculiar properties of zinc dust. Zinc dust is a by-product of the smelting furnaces; in the distillation of spelter from blende (Sphalerite) the amount of dust which sublimates in the flues will amount to perhaps 5 or 10% of the yield of spelter. It is mostly composed of impalpable particles of a blue-gray powder from [illegible] to [illegible] of an inch in diameter.

Zinc dust is zinc in a very unstable state, due to the sudden cooling to which the minute particles have been subjected; each particle is a tiny zinc "Rupert's drop." The chilled surface of these apparently perfectly spherical particles is undoubtedly oxidized, and this is a very important fact in considering the theory of [illegible]. Inside, the molecules of the metal are packed without regular order, it [illegible] and these molecules are [illegible] themselves in a more com[illegible] manner. This, however, cannot be [illegible] the shell in which they [illegible] the reaction of this catastro[illegible]. Hence, at a tem[illegible] that at which the metal [illegible] the zinc dust is con[illegible] with oxide.

[illegible] zinc volatilizes is [illegible] point is 419° C., yet [illegible] vapor in the neigh[illegible] closed receptacle is [illegible] dust and heated to [illegible] break down into [illegible] pressure. If [illegible] in the dust they [illegible] to the action [illegible] for a period of 5 [illegible] have condensed.

some zinc upon their surface and in their pores.

In practice, sherardizing (as it is named after its inventor, Sherard Cowper-Coles), is performed as follows: The articles to be coated are placed in a suitable retort—usually a cast-iron drum—and covered with commercial zinc dust; the retort is closed as tightly as possible, and even luted, to prevent the egress of the vapor, which is at a higher pressure than the atmosphere of the oven. The time during which the retort or drum will be left in the oven will depend on the deposit which it is desired to get. The retort is allowed to cool by natural means and the articles are taken out.

At first sight it seems strange that the drum itself should not be coated; this is due to its higher temperature; it emphasizes the fact that we are in the presence of a case of condensation like that of atmospheric moisture on a cold water-pipe. In the patent drums used for electrolytic work, motion is necessary to coat the object evenly.—Alfred Sang, in "Electrochemical and Metallurgical Industry."

Electrolytic Valve-Cells.—An electrolytic valve-cell consists of two electrodes immersed in an electrolyte, the combinations being such that through the chemical reactions the one electrode—generally the anode—becomes covered with a skin of some compound, which prevents the current from flowing in that direction. If we place such a cell on an alternating circuit, the pulses in one direction will be stopped, but those in the other will be able to pass.

The anode consists, as a rule, of aluminum; the metals of the rare earths, and those with which the search for new lamp materials have acquainted us, tantalum and niobium, further antimony, bismuth, cobalt, and, in certain solutions, copper, will also answer. The cathode is made of carbon, lead, iron, etc. The electrolyte may be an acid alkali, or a salt solution. many electrolytes have been tried with varying degrees of success, sulphuric acid and sodium phosphate perhaps most frequently. The aluminum covers itself, as anode during the formation period by direct currents, with a thin skin of oxide, hydrate, basic sulphate, phosphate, etc.; the skins are exceedingly thin, and their chemistry is not well established. The skin weakens or throttles the positive current, without completely stopping it as a rule, and there is a certain maximum, or critical, voltage depending upon the electrolyte, the surface condition of the electrode, and also on the temperature, which the aluminum will be able to stop. The critical voltage ranges, according to McCheyne Gordon, from 30 volts for sulphuric acid to 500 volts for citric acid; most organic acids are too easily destroyed to be suitable for technical application. Zimmermann has succeeded in stopping 1,250 volts. If the critical voltage is exceeded, sparks are seen, and the valve breaks down. When we place several valve cells on an alternating circuit, and provide two paths for the current, so that one way, and only one way, will remain open at any moment, we convert the alternating-current waves into unidirectional wave pulses. These pulses are more or less equalized with the aid of a condenser, so that continuous currents of fairly steady voltage result; it has been customary, since Bottone and Graetz first used electrolytic valve-cells, about 1891, to employ an electrolytic condenser for this purpose. This condenser forms a shunt across the two paralled valve-cell circuits, and is itself an electrolytic cell, whose two aluminum electrodes give a large leading current. Both the electrodes are coated with oxide skins, and the skins are supposed to be capable of holding positive charges only on the side next to the metal, and negative charges only on the side next to the electrolyte.

Electrolytic valve-cells are still regarded with a certain amount of distrust. They require judicious treatment, like accumulators, and may turn out as reliable and useful as batteries. In Germany they have successfully been applied in connection with train-lighting, and Dr. C. C. Garrard, of Messrs. Ferranti, Limited, proved their utility several years ago for preventing the arcs which occur when continuous-current circuits possessing inductance are interrupted. Dr. Garrard inserted a series of electrolytic cells across the break; the extra current passes through the cells and breaks down their resistance, which quickly restores itself. The critical voltage of the series should be a little above the line voltage. When the electrolytic cells are better understood they will find wider application.—"Engineering" (London).

Electric Smelting of Iron Ore.—A Heroult smelter has been recently installed in a California town bearing the name of the inventor of the process, and has proven entirely successful in the initial runs.

The smelter is elliptical in shape, containing

one compartment 5 ft. high, made of sheet steel lined with the finest magnesite brick. The bottom of the furnace is composed of heavy cast iron plates, overlaid with tamped carbon, which forms the neutral point of the circuit. A bed of asbestos insulates the lower portion of the furnace. The three carbon electrodes are 18 by 18 by 72 ins. and were imported from Sweden. They are fastened by wedges to a water-jacketed copper holder and may be raised and lowered mechanically. It has been found desirable to keep the electrodes in the slag rather than in the molten metal, as a better quality of the product is thus obtained.

The power employed is 3-phase 60-cycle alternating current, reduced from 22,000 volts to 50 volts by means of water-cooled transformers. The current employed at the lower voltage is 30,000 amperes.

The charge is composed of ore, charcoal, and limestone, and is fed to the furnace in a heated state. Four combination charging and draft tubes, each containing an inner steel tube and outer cast iron tube are placed near the top of the furnace. An annular space large enough for the combustion of the generated gases lies between the outer and inner tubes, and it is the burning of these gases which heats the charge as it passes through the inner tube to the furnace. A centrifugal pump supplies water for the cooling of the electrode holders and transformers. The suction pipe is sunk in still water.

The smelter is in the richest and most extensive iron region on the Pacific coast, and the ore can be transported from the mines to the smelter at a very low expense. The ore body as exposed on the surface is from 120 to 250 ft. wide, and lies between a formation of diorite and limestone. The limestone is so pure that it is being used for flux at the plant. The ore is magnetite and runs from 68 to 70 % iron, is practically free from sulphur, and with the exception of small sections along the contact, no sulphides are visible. The ore can be delivered at the smelter for about $1.35 per ton.

A vast amount of electrical power is available throughout the year, the power being generated in the Sierra Nevadas 30 miles from Heroult. The annual cost of electrical energy will be $12 per horse-power. The low cost of electrical power and transportation will permit the operators of the smelter to market their pig iron at a price far below that charged by the eastern manufacturers. Besides the deposits near Heroult, immense quantities of iron ore abound in other portions of Shasta county, and some of the metallurgists believe that the process can be utilized in the reduction of the vast copper deposits throughout the Shasta belt.

It is thought that the Shasta county magnetite can be converted into pig iron of the best grade and sold in San Francisco for about $16 per ton. The present price of pig iron in that city is $31 per ton. Practically all the iron used in California is imported from Europe and pays a heavy duty ($4 per ton).

Several promising beds of good coal are being mined in the Pitt river section, while a chromite ledge of immense size is being developed at Dunsmuir, a short distance from Heroult. The chromite is used for fluxing. With plenty of high-grade iron ore, excellent coal and fluxing materials, together with good transportation facilities, Heroult is expected to speedily develop into one of the most important industrial centers in the West.—From "The Mining World."

Lubricants are tested in about six ways: (1) By chemical analysis; (2) for specific gravity; (3) for relative viscosity when new; (4) for gumming action; (5) for flashing and burning points; (6) generally, by the testing machine. The last is the most efficient, and in its essential features consists of a pendulum hanging on the test journal, whose brasses can be adjusted for any pressure by a screw. The journal being rotated to the right, the pendulum moves to the left, and a scale at once indicates the friction per square inch of journal.

Moissan has found that, at its boiling point, copper dissolves graphite, and, upon cooling, the graphite is given out again in the form of more or less well defined crystals. This fact may explain the small black specks occasionally found in the fracture of brass castings. At the usual brass-melting temperature there is, undoubtedly, little absorption; but in overheated metal it may be possible that the dissolved graphite plays a more important part in weakening copper and its alloys than usually is supposed.

Elasticity in minerals not only involves the resistance of their molecules to complete separation but indicates such a development of cohesion as to prevent a permanent bending of the specimen and lead to its return to its original position when the disturbing force is removed. The micas exhibit this property to a marked degree.

BOOK DEPARTMENT

BOOKS ON CHEMISTRY.

Reviewed by August P. Bjerregaard.*

PRACTICAL METHODS OF INORGANIC CHEMISTRY.—By F. Mollwo Perkin, Ph.D. New York: D. Van Nostrand Co. Cloth; 5 × 7 ins.; pp. viii. + 155; illustrated. $1.00, net.

In the study of chemistry an ounce of experimental work actually done is worth a ton of reading or of listening to lectures. If, however, the student were left to himself in ever so good a laboratory, with ever so good a library of chemical books, but without any guide, it would be impossible for him to accomplish the most. He would, indeed, be in very much the same position as a person lost in a dense forest. To avoid needless waste of time in groping his own way, he needs someone to lead him in the right direction, who has been over the ground before him.

The majority of chemical books intended for students' use describe a larger or smaller number of elements and compounds, but usually give but slight attention to the details of experimental manipulation needed to prepare or to study them.

There have, indeed, appeared several books which aim to direct the student clearly through the vast maze of chemical compounds by means of the study of a limited number of typical compounds and reactions, carefully and systematically selected. Strange to say, however, the larger number of these books have treated of organic chemistry. A very few only have treated of what naturally forms the first subject of study, the inorganic compounds. Among the latter the book here reviewed is to be found.

Starting with a few general directions on the manipulation of the most common operations, the work gradually leads the student through the work of preparing some simple compounds of the metals, and through interesting preparations of increasing difficulty of various salts, halogens and halogen compounds, oxides, and acids, up to the elementary metals and metalloids themselves. Then the preparation of hydrazine by means of a beautiful train of work is described. Finally the subject of colloidal solutions is clearly and concisely dealt with.

Any student who faithfully performs the work put before him in this book will obtain a broad and clear view of inorganic chemistry, and will be in a position to undertake more advanced work with profit.

The directions are clearly written and are frequently illustrated by cuts of apparatus. Formulae for the reactions involved are usually given. No references to original periodical literature are given. There is an index. A few errors of proof-reading have been noticed; for instance, on page 129 occurs this surprising direction: "The supernatant liquid is poured off and washed several times by decantation." On page 25 the weight of magnesium taken is stated to be weight of silver taken. On page 145 the symbol for oxygen is printed 10.

The publisher's part of the work is well done as to paper, type and binding.

VAN NOSTRAND'S CHEMICAL ANNUAL, 1907.—First Year of Issue. Edited by John C. Olsen, A. M., Ph.D., with the Co-operation of Eminent Chemists. New York: D. Van Nostrand Co. Cloth; 5 × 7 ins.; pp. x. + 496. $2.50, net.

This is entirely a book of tables. Many numerical data of daily use in the chemical laboratory are here gathered together and conveniently arranged.

Various tables useful in the calculation of analyses, gravimetric, volumetric and gaseous, are first given. The principal bulk of the volume is taken up with two tables of the physical properties of numerous inorganic and organic substances. These tables give in columnar form data relating to the molecular weight, the specific gravity, melting and boiling points, crystalline form and solubility in cold and hot water, alcohol, and a few other common solvents. These solubility data are largely qualitative, although some quantitative determinations are also given.

Interspersed in the second of these tables

*Analytical Chemist, New York City.

are quite a number of original determinations by C. A. F. Kahlbaum.

Following these two tables is a group of specific gravity tables for various solutions. The Baumé scale here employed is exclusively the American standard. The standard specific gravity tables of the Manufacturing Chemists' Association of the U. S. for sulphuric acid, nitric acid, hydrochloric acid and ammonia are given among others. A few tables on the vapor density of water and mercury close this section. It is followed by some tables of equivalents of weights and measures. A section on the heats of combustion of various fuels follows. No thermochemical data are given for the heats of combination of the various elements or their compounds, among themselves. Lastly there are two lists of the more important chemical articles and books published since Jan. 1, 190[illegible].

On the whole the selections of material for this work have been well made, and it will doubtless take the place in America of similar works published abroad annually. The paper is good, the type is clear and easily read. There is a portrait of Sir William Ramsay as a frontispiece. The corners of the pages are rounded as are also those of the binding.

FUEL, WATER AND GAS ANALYSIS. For Steam Users. By John B. C. Kershaw, F. I. C. Author of "Smoke Prevention," etc. New York: D. Van Nostrand Co. Cloth, [illegible] ins.; pp. [illegible]; [illegible] illustrations in the text. $[illegible] net.

As fuels are so variable in quality and the efficiency of combustion is influenced by both the type of apparatus in which it is burnt, and the conditions of air supply [illegible] [illegible] intended [illegible] develop-

ment of power by means of steam, and though many of the operations described require a considerable amount of skill and knowledge of quantitative analysis, some of them can be carried out by any careful engineer.

Especially is this the case with the detailed instructions given for taking samples of either fuel, water, or gas, and when these have been followed the fee for the particular examination by a skilled chemist will be well repaid by the information resulting, showing how economy can be effected.

Part I deals with the origin and properties of natural fuels, with the methods of analysis and determination of heat value, and concludes with the practical application of the results.

Part II treats of water, its sources and characteristics, with methods of examination and the application of test results, and softening reagents.

Part III, on waste gases, describes the characteristics and methods of examination, as well as influence of the composition upon the efficient burning of the fuel. The appendix gives rules for sampling fuel and much useful information and tables relating to tests of fuel, water and waste gases.

There are 50 illustrations, and the whole work is of a thoroughly practical nature based upon extended experience.

As the proportion of volatile matter in fuel increases, its efficient burning with air in boiler furnaces becomes more difficult of accomplishment owing to its being accompanied either by the emission of smoke or by a thermal loss due to an excessive proportion of air: in either case there is a loss of heat.

The commercial value of fuel, therefore, cannot be judged by its gross thermal value, [illegible] from an examination of the [illegible] resulting from the [illegible] of being maintained in [illegible] the fuel has to be [illegible] Review (London).

[illegible] INTERNATIONAL DICTIONARY [illegible] Mass.: G. & C. Merriam [illegible] ins.; pp. [illegible] illustrations, includ-[illegible]

[illegible] this work, recently [illegible] of the growth [illegible] new words and phrases [illegible] the new [illegible] use, the [illegible] meanings, and [illegible] have been revived.

r-in-Chief, W. T. Harris, Ph.D., LL.D., States Commissioner of Education, judgment and study to the perfecting ain outlines of the work, and closely the whole Supplement line by line, he copy and again in the proof. Among ial editors were such men as Mr. Rusrgis, the eminent writer on Architec-. Ira Remsen, Pres. of Johns Hopkins; J. Brewer, Associate Justice of the preme Court; Prof. R. H. Chittenden, Sheffield Scientific School, Yale Univ.; S. Sheldon, of Harvard Univ., etc., addition to keeping the dictionary of the times, its typographical excels been preserved by the making of an new set of plates for the whole book. em have been incorporated certain y changes and additions. The Gazetd Biographical Dictionary have both refully revised and entirely reset. The r has been made to accord with the ensus returns and recent geographical ies. In the Biographical Dictionary a mber of new names have been inserted old data have been verified.

HES AND TURNOUTS.—By Howard apin Ives, Assistant Professor of Raild Engineering, Worcester Polytechnic titute. Worcester, Mass.: The Author. per; 5¾ × 8½ ins.; pp. 44; 25 figs. 50.

study consists of three articles which ly appeared in the "Journal of the er Polytechnic Institute." The aulls attention to the following points: he descriptions of the different forms hes and their effect on the lead; sece statements of practical conclusions und at various places in the text; and he design of the slip switch, the matheof which are believed to be original, ing been found elsewhere by the au-

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DREDGING.—By Capt. C. C. Longge, M. Inst. M. E., Mining and Conting Engineer, Author of "Hydraulic ning," "Glossary of Mining Terms," . Second and Revised Edition. Lon-: The Mining Journal. Cloth; 6 × ins.; pp. xiv. + 338; many full-page strations and folding plates. 20s. erican price, $8.

attractive, not only to the engineer, the unprofessional man who is finanterested in gold dredging and desires information as to the nature of the ry and the process by which his money or lost. The book affords him a pictorial means of attaining his object. The general subject is divided clearly and distinctly into thirty sections, and a very good index makes reference easy. The author's method has been less historical than practical; he has contented himself for the most part with illuminating those questions and problems which are directly connected with the application of dredging in the gold-bearing rivers of the world so far as it is known. Mr. Longridge has dealt in considerable detail with the constructional part of his theme, and supplemented lucid descriptions with capital illustrations. The very important question of how to separate and retain the gold after it has been raised by spoon, or pump, or bucket, is discussed systematically and in detail in the chapters 'Separation of the Material Dredged' and 'Gold Recovery Appliances,' references being made to the most modern means and contrivances. Other noticeable chapters are those treating of the disposal of the tailings; the working of the dredgers; the difficulties of dredging; selecting, prospecting and valuing ground; and centrifugal hydraulic dredging. Several excellent half-tone plates assist to make plain the means taken to put the tailings out of the way."—"Engineering" (London).

SEWAGE AND THE BACTERIAL PURIFICATION OF SEWAGE.—By Samuel Rideal, D. Sc. Third Edition, enlarged. New York: John Wiley & Sons. London: The Sanitary Publishing Co. Cloth; 6 × 9 ins.; pp. xii. + 355; 58 illustrations. $4.

It seems to be generally acknowledged among sanitary engineers that this work is the most comprehensive treatise on the subject in the English language, and the appearance of a third edition recently is only natural in view of the high standing which the book has won. The new edition is distinguished from those previously issued in having numerous references to the valuable experience gained during the last five years in bacterial methods of sewage disposal, and also in containing the conclusions of the Royal Commission on Sewage Disposal, so far as they have been published. Although sewage disposal by bacterial methods has received a great deal of attention in Great Britain, nevertheless the actual construction of works has been attended by difficulties due to official regulations that have been extremely irksome. Accordingly, the following note in the preface of the new edition of this book is interesting: "The Local Government Board has relaxed some of the rules

which have proved irksome in many districts, but as unfortunately works approved by them and constructed out of loans on deposited schemes, have in certain cases given rise to serious complaints and law suits, I hope that in the future it will be possible in England for authorities to carry out works which are likely to be more successful, if the expert, after or during construction, is allowed to make such modifications in design or working as in his opinion will result in a proper disposal." For the benefit of those who are not acquainted with the volume it may be added that it contains a full statement of the present views of the leading sanitary specialists concerning the character of sewage and the nature and causes of the various changes taking place in it before it is finally reduced to stable substances. After this general review of the scientific features of sewage changes, the author takes up methods of disposal by irrigation, filtration, chemical treatment, sterilization and the numerous bacterial processes by which treatment is effected by a rapid rate on restricted areas of land. He also gives information concerning sewage outfalls and the discharge of sewage into fresh and salt water, the agricultural value of effluents of bacterial plants and the characteristics of many trade effluents. The volume is well illustrated.—"Engineering Record."

PRINCIPLES OF HEATING.—A Practical and Comprehensive Treatise on Applied Theory in Heating. By William G. Snow, M. Am. Soc. M. E., Am. Soc. H. & V. E. New York: David Williams Co. Cloth; 6 x 9 ins.; pp. viii. + 160; 62 illustrations in the text, and 38 tables. $2.

This book consists for the most part of a collection of articles by the author, which have appeared at various times during the past few years in the "Metal Worker, Plumber and Steam Fitter." These articles, however, have been supplemented by reprints of other contributions to heating science by several writers. Included in the work are the results of numerous tests made by the author on various heating apparatus and systems, together with many original tables and charts which he has found to be of practical use in the solution of heating problems. About one-quarter of the book is devoted to a consideration of vacuum and vapor systems of heating, which have recently attracted considerable attention. The book is well indexed and the data contained are thus made readily accessible. Chapters are devoted to the following subjects: Heating power of fuels, boilers and commercial heaters; gas, oil and electricity vs. coal; the capacity and fuel consumption of house heating boilers; furnace tests; specific heat, the heating and cooling of air and humidity; heat given off by direct radiators and coils; the loss of heat by transmission, computing radiation; heating water; the flow of steam in pipes and the capacities of pipes for steam heating systems and for steam boilers; capacities of pipes for hot water heating; vacuum and vapor systems of steam heating.

GRINDING AND LAPPING TOOLS, PROCESSES AND FIXTURES.—A Practical Treatise and Toolmaker's Reference Work upon Precision Grinding and Grinding Processes, the Preparation and Use of Abrasives, Lapping Processes and Methods, etc. By Joseph V. Woodworth, Author of "Dies, Their Construction and Use," "Hardening, Tempering, Annealing and Forging of Steel," etc. New York and London: Hill Publishing Co. Cloth; 6 x 9 ins.; pp. ix. + 162; 137 illustrations in the text. $2.00.

This is a thoroughly practical, up-to-date book on the design, construction and use of machines and devices used for grinding and finishing machine parts to accurate dimensions. It is written by a man who is not only familiar with his subject, but who also knows how too express himself clearly in language that will be understood in the machine shop. The contents are as follows: I.—Grinding; conditions, rules, methods, processes, machines and attachments for accurate grinding; use and and preparation of abrasives. II.—Laps and lapping; construction and use of tools and processes for finishing gages, tools, dies and machine parts to accurate dimensions. III.—Construction, use and operation of grinding fixtures and jigs, for finishing repetition articles of metal, small hardened and tempered steel parts and special work. IV.—The hardening and tempering of interchangeable tool steel parts of delicate structure which require to be ground and lapped afterward. V.—Percentage of carbon crucible steel parts and tools should contain, temper colors to which they should be drawn, and degrees of heat for giving them proper tempers.

TEXT-BOOK OF MECHANICS.—By Louis A. Martin, Jr., A. M., M. E., Assistant Professor of Mathematics and Mechanics in Stevens Institute of Technology. Vol. II., Kinematics and Kinetics. New York: John Wiley & Sons. London: Chapman

& Hall, Ltd. Cloth; 4¾ × 7¾ ins.; pp. xiv. + 214; 91 figures in the text. $1.50, net.

This is the second volume of Professor Martin's elementary course in Mechanics, which is designed for the preparation of students for their later work in Applied Mechanics. Vol. I deals with Statics, while the present volume takes up Kinematics and Kinetics; a knowledge of plane analytic geometry and calculus is presupposed on the part of the student, but the work may be taken up, provided differential calculus has been completed and a course of integral calculus is being studied at the same time. Over 400 carefully prepared exercises are given for the purpose of thoroughly familiarizing the student with the applications of the formulas and principles which they embody. Chapters are included on the following subjects: Kinematics—Rectilinear motion of a particle; curvilinear motion of a particle; motion of a rigid body; Kinetics—Kinetics of a particle and of the mass-center of a rigid body, application of the equations of motion for translation and for rotation; work and energy; impact.

DETAILS OF MILL CONSTRUCTION.—By Hawley Winchester Morton, Architect. Boston, Mass.; Bates & Guild Co. Cloth; 9½ × 12½ ins.; 25 plates. $2.

A book of 25 plates, 9 × 12, showing in detail with explanatory notes such things as sills, base plates, door guards and pin blocks, pintals, wall coping, windows, gutters and closets. The author says in his preface that up to the present time very little has been shown to illustrate the line of work known as "Mill Construction," a proposition to which most of us will agree. The factory builder today, looking for a model from which to get ideas of factory construction has not at his disposal the same facilities the home builder possesses, and for that reason the work before us possesses undoubted merit and fills a vacancy in the literature on this class of construction. It cannot but be of assistance to the busy architect or builder as well, providing ready-to-use details, which, like the ready-made parts of the modern building, have merely to be fitted into place, and presto! the thing is done.

NEW BOOKS.

Building.

THE BUILDING MECHANICS' READY REFERENCE.—Stone and Brick Masons' Edition. By H. G. Richey, Superintendent of Construction U. S. Public Buildings. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Morocco; 4¼ × 6¾ ins.; pp. v. + 251; 232 illustrations in the text. $1.50, net.

Civil Engineering.

DAS MATERIAL UND DIE STATISCHE BERECHNUNG DER EISENBETONBAUTEN. With Special Reference to Building Construction. By Max Foerster, Professor of Structural Enginering at the Dresden Technical College. [Fortschritte der Ingenieurwissenschaften. Second Series, Part 13.] Leipzig, Germany: Wilhelm Engelmann. Paper; 7¼ × 11 ins.; pp. 248; 93 illustrations in the text. 6 marks; American price, $2.40.

RIVER DISCHARGE.—Prepared for the Use of Engineers and Students. By John Clayton Hoyt, Assoc. M. Am. Soc. C. E., Engineer in charge of Hydraulic Computations, U. S. Geological Survey, and Nathan Clifford Grover, Assoc. M. Am. Soc. C. E., Assistant Chief Hydrographer in charge of River Measurements, U. S. Geological Survey. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 6 × 9 ins.; pp. viii. + 137; 23 illustrations. $2.00.

Electrical Engineering.

ALTERNATING CURRENT ENGINEERING.—Practically Treated. By E. B. Raymond, Chief of Testing Department, General Electric Co. Third Edition, Revised and Enlarged, with an Additional Chapter on "The Rotary Converter." New York: D. Van Nostrand Co. London: Kegan Paul, Trench, Truebner & Co. Cloth; 5¼ × 7½ ins.; pp. vii. + 244; 104 illustrations in the text. $2.50, net.

ELEMENTS OF ELECTRIC TRACTION FOR MOTORMEN AND OTHERS.—By L. W. Gant, Lecturer in the Electrical Engineering Department of the Leeds Institute Technical School. New York: D. Van Nostrand Co. Cloth; 5½ × 8¾ ins.; pp. 217; 38 illustrations in the text. $2.50, net.

"NATIONAL ELECTRICAL CODE."—1907. Rules and Requirements of the National Board of Fire Underwriters for the Installation of Electric Wiring and Apparatus, as Recommended by the Underwriters' National Electric Association. Paper; 3½ × 5¾ ins.; pp. 153.

THE ELECTRICAL TRANSMISSION OF ENERGY.—A Manual for the Design of Electrical Circuits. By Arthur Vaughan Abbott, C. E., Am. Inst. E. E., Am. Inst. M. E., Am. Soc. C. E. and Am. Soc. M. E. Fifth Edition, entirely rewritten and enlarged. New York: D. Van Nostrand Co. London: Crosby Lockwood & Son. Cloth; 6 × 9 ins.; pp. xxx. + 674; 367 il-

lustrations in the text, 112 tables, 10 folding diagrams, and 16 full-page engravings. $5.00, net.

Industrial Technology.

HAND-BOOK OF AMERICAN GAS-ENGINEERING PRACTICE.—By M. Nisbet-Latta, M. Am. Gas Inst., M. Am. Soc. M. E. New York: D. Van Nostrand Co. Cloth; 5¾ × 8½ ins.; pp. xi. + 466; 98 illustrations in the text and many tables. $4.50, net.

INDUSTRIAL ALCOHOL.—The Production and Use of Alcohol for Industrial Purposes and for Use as an Illuminant and as a Source of Motive Power. By John Geddes McIntosh, Author of "The Technology of Sugar," etc., Lecturer on Manufacture and Applications of Industrial Alcohol at the Polytechnic, Regent Street, London. London: Scott, Greenwood & Son. New York: D. Van Nostrand Co. Cloth; 5½ × 8½ ins.; pp. viii. + 252; 78 illustrations in the text. $3, net.

Mechanical Engineering.

DIE HERSTELLUNG DER DAMPFKESSEL.—By M. Gerbel. Berlin, Germany: Julius Springer. Paper; 5½ × 8¼ ins.; pp. 82; 60 illustrations in the text. 2 marks; American price, 80 cts.

GAS AND OIL ENGINES AND GAS-PRODUCERS.—A Treatise on the Modern Development of the Internal-Combustion Motor and Efficient Methods of Fuel Economy and Power Production. Part I: Gas and Oil Engines. By Lionel S. Marks, S. B., M. M. E. Part II: Gas Producers. By Samuel S. Wyer, M. E. Chicago: American School of Correspondence. Cloth, 6½ × 9½ ins.; pp. 144; 93 illustrations in the text. $1.00.

GRINDING AND LAPPING TOOLS, PROCESSES AND FIXTURES. A Practical Treatise and Toolmaker's Reference Work upon Precision Grinding and Grinding Processes, the Preparation and Use of Abrasives, Lapping Processes and Methods, etc. By Joseph V. Woodworth, Author of "Dies, Their Construction and Use," Hardening, Tempering, Annealing and Forging of Steel," etc. New York and London: Hill Publishing Co. Cloth; [illegible] × 8 ins.; pp. x. [illegible] 152; 137 illustrations in the text. $2 [illegible]

ON THE ART OF CUTTING METALS.—By [illegible] W. Taylor. [illegible] Address Made at the Opening of the Annual Meeting in New York, December [illegible]. New York: The American Society of Mechanical Engineers. [illegible]

PRINCIPLES OF [illegible] Construction [illegible] Snow [illegible] New York: [illegible] Williams Co. Cloth; [illegible] 67 illustrations in the text and [illegible] $2.

TEXT-BOOK OF MECHANICS.—By Louis A. Martin, Jr., Am. M. E., Assistant Professor of Mathematics and Mechanics in Stevens Institute of Technology. Vol. II., Kinematics and Kinetics. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 4¾ × 7¾ ins.; pp. xiv. + 214; 91 figures in the text. $1.50, net.

Mining Engineering.

ELECTRICITY IN MINING.—By Sydney F. Walker, M. Inst. E. E., M. Inst. Min. E., Assoc. M. Inst. C. E., etc. New York: D. Van Nostrand Co. Cloth; 5½ × 8¾ ins.; pp. 385; 31 plates and 163 text illustrations. $3.50, net.

THE PRINCIPLES AND PRACTICE OF COAL MINING.—By James Tonge, M. Inst. M. E., F. G. S. London, England: Macmillan & Co., Ltd. New York: The Macmillan Co. Cloth; 4¾ × 7½ ins.; pp. 363; 203 illustrations in the text. 5s., net; American price, $1.60, net.

Sanitary Engineering.

CLEAN WATER AND HOW TO GET IT.—By Allen Hazen, M. Am. Soc. C. E., Am. Water-Works Assn., etc. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 5½ × 7¼ ins.; pp. x. + 178; many half-tone illustrations. $1.50.

THE DISPOSAL OF MUNICIPAL REFUSE.—By H. de B. Parsons, Consulting Engineer, M. Am. Soc. C. E. and Am. Soc. M. E.; Author of "Steam Boilers: Their Theory and Design." New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 6 × 9 ins.; pp. x. + 186; 73 illustrations, mostly full-page plates. $2.

The latest annual catalogue of The Macmillan Company, which has just been issued, has been prepared in accordance with a new plan that gives it more than passing value. It is arranged on the plan of a dictionary, author and subject entries following one another in one alphabetical list. The catalogue contains a complete list of all books published by this company which are still in active demand, and it is especially valuable because these include the more important publications issued in the last [illegible] years or more by a number of the [illegible] publishing houses. It is announced by the publishers that the total number [illegible] is nearly six thousand and that [illegible] hundred different authors [illegible]. The wide range of subjects [illegible] publications of this one house [illegible] of Subject Headings, [illegible] the convenience of librarians [illegible] arranged in conformity with [illegible] classification used by [illegible] Association.

CORRESPONDENCE AND INQUIRIES

Space in this department will be devoted to answers to inquiries regarding available literature on different subjects. Such inquiries will be answered briefly by stating the names of a few of the more important references to the subjects mentioned, without specifying the advantages or disadvantages of any competing works. Detailed descriptions can always be obtained by writing to any of the dealers advertising in Technical Literature, most of whom handle the books of all publishers. Where immediate and personal attention to a communication is desired, stamps must be enclosed for reply.

Miscellaneous Scientific Books.

We are considering the installation of a small library at one of our plants, and would be pleased to have your recommendation of some books on general engineering and scientific subjects. A. B. Co., New York.

A suitable list for such a purpose was published in Technical Literature for June, under the title of "A $500 Technical Library." The Engineering News Book Department has reprinted this list for circulation with some slight changes and additions, as a "Medium-priced Technical Library."

Salt.—A. R. C. Co., New York.

The best brief treatment of this subject is in Thorp's "Industrial Chemistry" (The Macmillan Co., $3.75), which explains the solar process and other methods of production.

Cinder Concrete.—B. M., Indianapolis.

We know of no book treating exclusively of this subject. It is touched on to a greater or less extent in several works on concrete, especially in Reid's "Concrete and Reinforced Concrete Construction." (M. C. Clark Publishing Co, $5.00). Articles on the subject appeared in "Engineering News" of Dec. 13, 1900, and Jan. 3, 1901.

Cement, Concrete, and Reinforced Concrete.

More inquiries for information on these subjects have been received than on any others, and on account of this evident interest we append a list of the current books, exclusively or partly treating of concrete and cement. Detailed information regarding these may be had from retail dealers or by addressing this journal. In the January issue of Technical Literature was published a general review of the current books on reinforced concrete, by Mr. L. S. Moissèiff, of the New York Bridge Department, and in this issue we present a review of the current periodical literature on the subject by Mr. A. W. Buel.

The list of books is as follows:

Cement and Concrete. By Louis C. Sabin. 2d Edition. (McGraw, $5.00).

Treatise on Concrete, Plain and Reinforced. By Frederick W. Taylor and Sanford E. Thompson. (Wiley, $5.00).

Reinforced Concrete. By A. Considère. Translated from the French by Leon S. Moisseiff. Second Edition. (McGraw, $2).

Reinforced Concrete. By A. W. Buel and C. S. Hill. Second Edition. (Engineering News, $5.00, net).

Concrete and Reinforced Concrete Construction. By Homer A. Reid. (M. C. Clark Co., $5.00, net).

Reinforced Concrete. By Charles F. Marsh and William Dunn. Third Edition. (Van Nostrand, $7.00).

Handbook on Reinforced Concrete. By F. D. Warren. Second Edition. (Van Nostrand, $2.50).

Architects' and Engineers' Handbook of Reinforced Concrete Constructions. By L. J. Mensch. ($2.00).

Concrete Steel. By W. N. Twelvetrees. (Price, $1.90).

Graphical Handbook for Reinforced Concrete Design. By John Hawkesworth, C. E. (Van Nostrand, $2.50).

Brayton Standards for the Uniform Design of Reinforced Concrete. By Louis F. Brayton. Second Edition. ($3.00).

Theory of Steel-Concrete Arches and of Vaulted Structures. By William Cain. (Van Nostrand, 50 cents).

Concrete Factories. By Robert W. Lesley. ($1.00).

Instructions to Inspectors on Reinforced Concrete Construction. By George P. Carver. (50 cents).

Handbook for Cement Users. By Chas. C. Brown. Third Edition. ($3.00).

Cement Worker's Handbook. By W. H. Baker. (Engineering News, 50 cents).

The Cement Industry. ($3.00).

Concrete Block Manufacture. By Harmon H. Rice. (Wiley, $2.00).

Manufacture of Concrete Blocks and Their Use in Building Construction. By H. H. Rice, Wm. M. Torrance, and others. (Engineering News, $1.50).

Hollow Concrete Block Building Construction. By Spencer B. Newberry. (50 cents).

Artificial Stone, Terra Cotta, etc. Edited By John Block. (25 cents).

Directory of American Cement Industries, 1906. By Charles C. Brown. ($5.00).

Handbook of Cost Data. By Halbert P. Gillette. (M. C. Clark Co., $4.00).

Cements, Mortars and Concretes. By Prof. Myron S. Falk. (M. C. Clark Co., $2.50, net).

Experimental Researches Upon the Constitution of Hydraulic Mortars. By H. Le Chatelier. Translated by Joseph L. Mack. ($2.00).

Portland Cement. By Richard K. Meade, B. S. (Chemical Publishing Co., $3.50).

Cements, Limes and Plasters. By Edwin C. Eckel. (Wiley, $6.00).

Practical Cement Testing. By W. Purves Taylor. (M. C. Clark Co., $3.00).

Hydraulic Cement. By Frederick P. Spalding. (Wiley, $2.00).

Portland Cement, Its Manufacture, Testing and Use. By David B. Butler. ($5.25).

Calcareous Cements. By Gilbert R. Redgrave and Chas. Spackman. Second Edition. ($4.50).

Hydraulic Power Plants.—P. N., Los Angeles, Cal.

The most modern books treating of this subject in a style suitable for a beginner.

Of the several good books on the subject of Power Plants, those best answering the requirements are:

Beardsley's "Hydroelectric Plants.". (McGraw, $5.00, net).

A hydraulic and hydroelectric engineer's handbook, covering hydraulic principles, measurement of flow, reconnoisance of water power, materials, hydraulic construction, power house construction and equipment, and power transmission.

Hutchinson's "Long Distance Electric Power Transmission." Third Edition. (Van Nostrand, $3.00, net).

A treatise on the hydroelectric generation of energy; its transformation, transmission and distribution.

Cost Data.—T. R. L., New York.

Is there any book on cost estimating in building construction similar to Gillette's "Cost Data"?

The only one that can lay any serious claims to actual usefulness is Arthur's "The Building Estimator." ($1.50).

This is a small handbook of 184 pages, in which the author has succeeded in crowding a great deal of valuable cost data covering a wide range of subjects. It is published by the author in Omaha, Neb., and much of the data are based on the ruling prices of that district. At the same time the book appears to be the most complete of its class yet published. It can probably be supplied by any of the dealers advertising in Technical Literature.

Sea-Coast Work.—D. B., Montreal, Canada.

Treating of harbors, coast protection, jetties, etc.

Wheeler's "The Sea Coast: Destruction, Littoral Drift, Protection." (Longmans, $4.50).

Wheeler's "Tidal Rivers: Their Hydraulics, Improvements and Navigation." (Longmans, $5.00).

Colson's "Notes on Docks and Dock Construction." (Longmans, $7.00).

Cunningham's "Treatise on Principles and Practice of Dock Engineering." (Lippincott, $9.00).

Shields: "Principles and Practice of Harbor Construction." (Longmans, $5.00).

Contract Law.—E. P. B., Chicago.

The works on this subject by Mr. John C. Wait have long been recognized as the standards. These are:

Wait's "Engineering and Architectural Jurisprudence." ($6.00).

Covers the law of construction for engineers, architects, contractors, builders, public officers and attorneys.

Wait's "Law of Operations Preliminary to Construction." ($5.00).

Rights in real property, boundaries, easements and franchises.

Wait's "Law of Contracts." ($3.00).

A text-book on the subject.

These are published by John Wiley & Sons. Besides these are Johnson's "Engineering Contracts and Specifications" ($3.00) and Waddell and Wait's "Specifications and Contracts" ($1.00) (in press), published by the Engineering News Book Department, and "A Lecture on the Law of Contracts," by John Mason Brown. ($1.00).

Curve Tables in the Metric System.—E. E. B., Mexico.

Handbook of Curve Tables giving functions of the metric curve.

Allen's "Table of Parabolic Curves." (Spon, $2.00).

Published specially for use in countries using the metric system, and used extensively in South American countries.

Mathematical Tables.—C. B., San Francisco.

Chamber's "Mathematical Tables." (Van Nostrand, $1.75).

Claudel's "Handbook of Mathematics." (McGraw, $3.50).

Water Pipes and Joints.—J. B. C., Toronto, Canada.

A pamphlet entitled "Standard Specifications for Cast-Iron Pipe and Special Castings," gives this information. The specifications were adopted Sept. 10, 1902, by the New England Water-Works Association and were published by the Society in 1903. (Price, 10 cents).

THE EDUCATION AND TRAINING OF ENGINEERS*

By SYLVANUS P. THOMPSON, D. SC., F. R. S.

rplay of action and reaction make for ss not only in the evolution of the sci- industries, but also in the development individual engineer. In him, if his g is on right lines, pure theory becomes to sound practice; and practical appli- are continually calling him to resort se abstractions of thought, the underly- inciples, which, when known and formu- are called theories. Recent years have t about a so much better understand- education, in its bearing upon the pro- s and constructive industries, that we eldom hear the practical man denounc- eory, or the theorist pooh-poohing prac- It is recognized that each is useful, and e best uses of both are in conjunction, isolation. As a result of this better tanding distinct progress is being made training of engineers. Of this the growth engineering departments of the univer- and of the technical colleges and , affords striking evidence. The tech- chools, moreover, are recognizing that tudents must have a sound preliminary ion, and are advancing in the require- they expect of candidates for admission. re also finding out how their work may upplement the practical training in the and are improving their curricula ac- gly. In the engineering industry, too, Britain is slowly following the lead in America, Germany, and Switzerland, recognition afforded to the value of a atic college training for the young en- , though there is still much apathy and istrust shown in certain quarters. Yet is no doubt that the stress of competi- particularly of competition against the ry and the enterprise of the trained men er nations, is gradually forcing to the he sentiment in favor of a rational and scientific training for the manufacturer and for the engineer. As William Watson, in his "Ode on the Coronation," wrote in a yet wider sense of England:

> For now the day is unto them that know,
> And not henceforth she stumbles on the prize;
> And yonder march the nations full of eyes.
> Already is doom a-spinning. . . . .

Truly the day is "unto them that know." Knowledge, perfected by study and training, must be infused into the experience gained by practice; else we compete at very unequal odds with the systematically trained workers of other nations. Nor must we make the mistake here in the organization of our technical institutions of divorcing the theory from its useful applications. In no department is this more vital than in the teaching of mathematics to engineering students. For while no sane person would deny that the study of mathematics, for the sole sake of mathematics, even though it leads to nothing but abstract mathematics, is a high and ennobling pursuit, yet that is not the object of mathematical studies in an engineering school. The young engineer must learn mathematics, not as an end in itself, but as a tool that is to be useful to him. And if it is afterwards to be of use to him, he must learn it by using it. Hence the teacher of mathematics in an engineering school ought himself to be an engineer. However clever he be as a mathematical person, his teaching is unreal if he is not incessantly showing his learners how to apply it to the problems that arise in practice; and this he is incapable of doing if these problems do not lie within his own range of experience and knowledge. Were he a heaven-born senior wrangler, he is the wrong man to teach mathematics if he either despises or is ignorant of the ways in which mathematics enter into engineering. The fact is that for the great majority of engineering students, the mental training they most need is that which will enable them to think in physics, in mechan-

*cts from address to the Engineering Section the Leicester meeting of the British Association Advancement of Science.

ics, in geometric space, not in abstract symbols. The abstract symbols, and the processes of dealing with their relations and combinations, are truly necessary to them; but they are wanted not for themselves, but to form convenient modes of expressing the physical facts and laws, and the interdependence of those physical facts and laws. When the student looses grip of the physical meaning of his equations, and regards them only as abstractions or groupings of symbols, woe betide him. His mathematics amount to a mere symbol juggling. That is how paper engineers are made. The high and dry mathematical master who thinks it beneath him to show a student how to plot the equations $y = A \sin x$, or $r = b \sin \theta$, or who never culls an exomple or sets a problem from thermodynamics or electricity, must be left severely on one side as a fossil. Better a living Whitworth scholar than a dry-as-dust Cambridge wrangler. Heat least knows that elasticity is something more real than the group of symbols $E = p \div \Delta x/x$, which any mathematician may "know," even though he be blissfully ignorant whether the force required to elongate a square-inch bar of steel by one one-millionth of its length is 10 oz. or 10 tons.

One evidence of the wholesome change of opinion that is springing up concerning the training of engineers is the abandonment of the system of taking premium pupils into works with no other test or qualification than that of the money-bag. Already many leading firms of engineers have been finding that the practice of taking sons of wealthy parents for a premium does not answer well, and is neither to their own advantage nor in many cases to that of the "pupil," whom it is nobody's particular business in the shops to train. Premium pupilage is absolutely unknown in the engineering firms of the United States or on the Continent of Europe. The firms who have abandoned it are finding themselves better served by taking the ablest young men from the technical schools and paying them small wages from the first, while they gain experience and prove themselves capable of good service. Messrs. Yarrow & Co. have led the way with a plan of their own, having three grades of apprenticeship, admission to which depends upon the educational abilities of the youths themselves. Messrs. Siemens have adopted a plan of requiring a high preliminary training. The Daimler Motor Company has likewise renounced all premiums, preferring to select young men of the highest intelligence and merit. Messrs. Clayton and Shuttleworth have quite recently reconstructed their system of pupil-apprenticeship on similar lines. The British Westinghouse Company and the British Thomson-Houston Company have each followed an excellent scheme for the admission of capable young men. Even the conservatism of the railway engineer shows signs of giving way; for already the Great Eastern Railway has modernized its regulations for the admission of apprentices. What the engineering staffs of the railway companies have lost by taking in pupils because of their fathers' purses rather than for the sake of their own brains it is impossible to gauge. But the community loses too, and has a right to expect reform.

To this question, affecting the whole future outlook of engineering generally, a most important contribution was made in 1906 by the publication by the Institution of Civil Engineers of the report of a Committee—appointed in November, 1903—to consider and report to the Council upon the subject of the best methods of education and training for all classes of engineers. This Committee, a most influential and representative body consisting of leading men appointed by the several professional societies, the Institutions of Civil, Mechanical and Electrical Engineers, the Institution of Naval Architects, the Iron and Steel Institute, the Institution of Gas Engineers, the Institution of Mining Engineers, and two northern societies, was ably and sympathetically presided over by Sir William H. White. Its inquiries lasted over two years, and included the following sections: (1) Preparatory Training in Secondary Schools; (2) Training in Offices, Workshops, Factories, or on Works; (3) Training in Universities and Higher Technical Institutions; (4) Post-graduate Work. The findings of this Committee must be received as the most authoritative judgment of the most competent judges. So far as they relate to preparatory education they suggest a modernized secondary school curriculum in which there is no one specialized scientific study, but with emphasis on what may be called sensible mathematics. They also formulated one recommendation so vital that it must be quoted in full: "A leaving examination for secondary schools, similar in character to those already existing in Scotland and Wales, is desirable throughout the United Kingdom. It is desirable to have a standard such that it could be accepted by the Institution [of Civil Engineers] as equivalent to the

Studentship Examinations and by the Universities and Colleges as equivalent to a Matriculation Examination."

One may well wonder why such a reasonable recommendation has not long ago been carried out by the Board of Education. Perhaps it has been too busy over the religious squabble to attend to the pressing needs of the nation.

The second set of recommendations relates to engineering training. It begins with the announcement that "long experience has led to general agreement among engineers as to the general lines on which practical training should proceed;" but goes into no recommendations on this head beyond favoring four years in workshops, on works, in mines, or in offices, expressing the pious desire that part of this practical training should be obtained in drawing-offices, and suggesting that during workshop training the boys should keep regular hours, be subject to discipline, and be paid wages. It then lays down a dozen recommendations as to the "academic" training suitable for the average boy. He should leave school about seventeen; he should have a preliminary year, or introductory workshop course of a year, either between leaving school and entering college, or after the first year of college training. If the workshop course follows straight on leaving school there must be maintenance of studies either by private tuition or in evening classes, so that systematic study be not suspended. For the average student, if well prepared before entering college, the course should last three academic years—three sessions—in some cases this might be extended to four or shortened to two. A sound and extensive knowledge of mathematics is necessary in all branches of engineering, and those departments of mathematics which have no bearing upon engineering should not claim unnecessary time or attention. The Committee strongly recommends efficient instruction in engineering drawing. The college course should include instruction—necessarily given in the laboratory—in testing materials and structures, and in the principles underlying metallurgical processes. In the granting of degrees, diplomas, and certificates, importance should be attached to laboratory and experimental work performed by individual students, and such awards should not depend on the results of terminal or final examinations alone.

All this is most excellent. It will be seen that it is entirely incompatible with the premium-pupil system, which may therefore be regarded as having been weighed and found wanting. For two things clearly stand out: that the young engineer must be college-trained, and that when he goes to works he should be regularly paid. It would have been well if the Committee could have been more explicit as to the proper course of workshop training; for instance, as to the systematic drafting of the young engineer through the shops—forge, foundry, pattern-shop, fitting-shop, etc., and as to the proper recognition of the duty of the shop foreman to allocate work to the novice in suitable routine. These are doubtless among the matters in which "long experience has led engineers to general agreement." But this being so, it would have been well to state them authoritatively. A notable feature of this report is its healthy appreciation of the advantages of training, and an equally healthy distrust of the practice of cramming for examinations. So soon as any subject is crammed, it ceases to afford a real training. "Nature provides a very convenient safety valve for knowledge too rapidly acquired." It is even whispered that a new species of crammer has arisen to "prepare" candidates in engineering for the graduate examinations of the Institution of Civil Engineers. The distinguished framers of this epoch-making report on the education and training of engineers at least give no countenance to any such parasitical development. For the scheme of education and training at which the Committee has aimed is genuinely scientific, a happy federation of the theoretical with the practical. It seeks to place the training on a broad basis, and to secure to every future engineer worthy of the name the advantage of learning his professional work in both its aspects. It seeks, in short, to take advantage of that reflex action between science and its applications in which lies the greatest stimulus to progress. Its adoption will utilize for the young engineer, and therefore for the engineering industry as a whole, the facilities for training now so widely afforded throughout the country. If the institutions, schools, and colleges where engineering training is offered are but rightly developed and co-ordinated, the engineers of Great Britain need have no fear as to holding their own against the trained engineers of other countries. It is for the employers to make use of these institutions, and to show that sympathetic interest in their efficiency which is essential to their full success.

PERSONAL.

Dr. William Freeman Myrick Goss has resigned as dean of the schools of engineering and director of the engineering laboratory, Purdue University, Lafayette, Ind., to become dean of the college of engineering, University of Illinois, Champaign, Ill. Dr. Goss was born at Barnstable, Mass., on October 7, 1859. After a course at the Massachusetts Institute of Technology, he went to Purdue in the fall of 1879 and organized the department of practical mechanics, of which he ever since has been the head. Dr. Goss is very widely known in the railway field by reason of the extended investigations of locomotive performance which he has conducted at the Purdue laboratories during the last 16 years. The principal results of Dr. Goss' work on the locomotive were published recently in his "Locomotive Performance." More than any other man who has been engaged primarily in university educational work, Dr. Goss has been identified with the practical affairs of railways and is recognized as an authority of the highest standing in matters pertaining to the mechanical department. The deposit at Purdue of much of the experimental apparatus of the railway mechanical associations, and the donations to the railway museum of the university are quite as much a personal tribute to Dr. Goss as to the prestige of the university, which is so largely due to him. Dr. Goss has been a member of the American Railway Master Mechanics' Association since 1895, and of the Master Car Builders' Association since 1902. He is a member of the Western Railway Club and served as its president in 1901, and is a member of the American Society of Mechanical Engineers and of other associations of engineers and educators. Recently he was chosen by the Carnegie Institution of Washington to carry on special investigations relative to superheated steam for locomotives.

Prof. Charles Henry Benjamin has been appointed dean of the school of engineering of Purdue University. He will succeed Prof. W. F. M. Goss, who has resigned to accept a similar appointment in the University of Illinois. Professor Benjamin has held the chair of mechanical engineering in the Case School of Applied Science since 1889, previous to which time he was for three years engaged in the practice of engineering and for six years professor of mechanical engineering in the University of Maine, his alma mater.

Stevens Institute of Technology.—John C. Ostrup has been appointed professor of structural engineering. Professor Ostrup is a graduate of the Polytechnic School in Copenhagen, Denmark, later studying at the Chicago Engineering School, and has had a large and varied experience in important work extending over 17 years.

OBITUARY.

Leveson Francis Vernon-Harcourt, M. Inst. C. E., one of England's distinguished engineers, and one of wide experience in river and harbor work, etc., died on Sept. 14 at Swanage, England. He was the youngest son of the late Admiral F. E. Vernon-Harcourt, and was born in 1839. His early education was received at Harrow, and he afterwards went to Baliol College, Oxford, where he took degrees in 1861 and 1862. For three years thereafter he was with the late Sir John Hawkshaw, F. R. S., President in 1861 of the Institute of Civil Engineers; he then became Resident Engineer of the Southwest India Dock Works. After holding various other positions in the line of harbor work, he began practicing as a consulting engineer in 1878, at the age of 39. In 1882 he was appointed Professor of Civil Engineering at University College, London, and was made Emeritus Professor in 1906.

Mr. Vernon-Harcourt was regarded as an authority on canal and river engineering, and particularly on the subject of hydraulic canal lifts. In 1904 he was a member of the International Jury at Vienna, on projects for canal lifts; for his services at that time he was made a Commander of the Imperial Franz Josef Order of Austro-Hungary. The deposition of silt in channels and at ports was also one of his principal studies.

In 1896 Mr. Vernon-Harcourt went to India to make a report to the Port Commissioners of Calcutta on the improvement of the Hooghly River. He also served on the Juries of Award for Civil Engineering at the Paris Exposition of 1900 and the Louisiana Purchase Exposition in 1904. In 1905 he represented England at the Navigation Congress held at Milan, and in 1906 was appointed as British member of the Consultative Commission for the Suez Canal.

His literary work was quite extensive, embracing many professional papers and a number of standard volumes, among the latter being "Rivers and Canals" and "Harbors and Docks." His latest work on water supply and sewage disposal was published early in the present year.

ELECTRIC DYNAMOMETERS FOR TESTING GASOLENE ENGINES.

The difference between the new and the old method of testing gasolene engines in factories before shipment, is largely responsible for the success attained by these machines during the past few years. The old method consisted in running the engine by its own power long enough to assure the tester that the working parts were running smoothly, but no measurements were made of the power the engine developed. In the new method the engine is loaded, and accurate tests under these conditions are made of the actual brake horse-power developed by the engine.

The electric dynamometer offers an easy, accurate, and efficient means of obtaining instantaneous values of the brake horse-power of an engine and also of placing full load on it for a long time without excessive heating of the dynamometer. The brake horse-power of an engine operating at different speeds can be readily determined with great precision, and owing to the simplicity of the apparatus and calculations, the test can be made by comparatively inexperienced attendants.

The electric dynamometer built by the Sprague Electric Company is specially designed for absorbing and measuring the power developed by gasolene engines in factory tests. It is also suitable for testing any type of engine or motor, and for measuring power from any mechanical source. This dynamometer differs from the well-known Prony brake in that the reaction of friction is replaced by an electro-magnetic reaction—an advantage of great importance.

The general arrangement of the electric dynamometer, shown in the accompanying illustration, consists of a specially constructed direct-current generator with compensating poles. The generator field frame consists of a cylindrical magnet yoke to the inner side of which the poles are bolted, each pole supporting a field coil. Brackets which contain the bearings are bolted to the end of the yoke, the front bracket carrying the rocker arm. Special bosses are cast on the end brackets for receiving ball bearings which support the entire generator in such a manner as to permit the field frame to oscillate concentric with the armature.

The movement of the field frame is limited by means of a stud on the outside of the yoke which projects through a slot in a forging secured to the side of the supporting frame. The length of the slot therefore determines the arc through which the field frame can move.

Two arms, one short and the other longer, extend horizontally from opposite sides of the field frame to which they are rigidly secured. The short arm carries at its outer end a metal box to receive the necessary amount of lead to

ELECTRIC DYNAMOMETER OF THE SPRAGUE ELECTRIC CO., NEW YORK.

counter-balance the field frame on its ball bearings. The long arm is provided at its outer end with a hanger similar to that on an ordinary platform scale, on which slotted weights may be placed.

The engine to be tested is set in position and bolted to the supporting frame in allinement with the dynamometer. The two shafts are then connected together with a flexible coupling and the engine started.

The torque exerted by the armature is transmitted to the field and tends to rotate the field frame in the same direction as that in which the armature is turning. By placing weights on the hanger attached to the long arm previously mentioned, the torque is readily measured.

The horse-power developed by the engine may then be found by using the following

formula. In this formula W = the weight in pounds on the hanger, D = the distance in feet from the center of the armature to the weight, and S = the speed of the engine in revolutions per minute.

$$HP = \frac{W \times 2D \times 3.1416 \times S}{33,000}$$

It will be noted in this formula that the only variables with a given dynamometer are the weight W and the speed S. If a curve be drawn or a tabulation made showing the horse-power developed at different speeds, an ordinary mechanic can perform the tests without making any calculations. The voltage and current produced by the dynamometer do not enter into the calculations.

In some cases it is possible to utilize the current generated by the dynamometer by connecting direct to the shop wires and operating the dynamometer in parallel with the generators already in service. Under these conditions variations in the engine speed can be obtained very easily by adjustment of the rheostat in the field circuit of the dynamometer.

If it is not convenient to utilize in this way the current generated by the dynamometer, it can readily be absorbed or dissipated in a water rheostat.

With the arrangement just mentioned, in which the dynamometer is operated in parallel with the shop generators, it is also possible to use the dynamometer as a motor to start the engine, taking power from shop mains or an [illegible]

[illegible]

by the dynamo when driven by the engine. The losses in the dynamo which vary with the load must then be taken into consideration. This task is a tedious one and the results are usually in doubt. Other methods are often found objectionable on account of the very fine adjustments required, limited speed variations, etc.

Electric dynamometers are manufactured by the Sprague Electric Company, in sizes from 10 to 100 horse-power, and any one of these sizes is capable of operation over a wide range of speeds and loads. A structural steel frame for supporting the dynamometer and gasolene engines of various sizes is also provided.

FLEXIBLE FLANGE UNION.

In this union, practically all of the difficulties found with the ordinary flange are eliminated, and the difficulties of erecting piping with flanged joints are almost entirely removed.

As shown by the illustration, these unions are made of the highest grade of materials, and each end of them has a brass seat screwed in.

[illegible] UNION OF THE WESTERN [illegible]

[illegible] the brass seat and [illegible] for the flanges [illegible] angle, and the [illegible] to some lo- [illegible] screwed tight on the [illegible] The use of [illegible] metal in the [illegible] packing or gas- [illegible] that each [illegible] test un- [illegible] is re- [illegible] made by the [illegible] sizes to [illegible] and [illegible] finish.

LIFTING MAGNETS.

Although the laws governing electro-magnets have been well-known for years, the manufacture of lifting magnets for commercial purposes is still an infant industry. The number of commercial magnets actually in use in the United States today is relatively small, taking into consideration the immense number of plants in this country which could profitably employ lifting magnets for handling various forms of raw metals and finished parts entering into the products of their manufacture. This condition is doubtless in large part due to the fact that the advantages of lifting magnets are not generally realized, for it is worthy of note that no concern that has given the lifting magnet a fair trial has returned to the old method of handling iron and steel.

Wherever pig-iron, metal plates, tubes, rails, beams, scrap or heavy casting of iron or steel are handled, lifting magnets can be advantageously employed. The saving in time alone in adjusting hoisting tackle to the object to be raised is of itself often sufficient to justify the installation of a lifting magnet, while in the case of pig-iron, plates, rails and scrap the practical advantages of lifting magnets are still more obvious owing to the large number of pieces that can be handled at a single lift and to the fact that the objects so handled need not be piled beforehand. All that is necessary in work of this sort is to lower the magnet into the objects to be handled, switch on the current—and lift. A further advantage of lifting magnets is found in the fact that metal too hot to be touched with the fingers, can be handled as easily as cold metal.

Various forms of material require various forms of magnets. The construction of magnets for handling plates, or material of a similar nature, affording opportunity to secure an intimate magnetic contact is a comparatively simple problem. In such cases the principal care of the designer will be to provide means for securely anchoring and properly insulating the magnetizing coil. Calculations as to the lifting capacity of such a magnet can be made with considerable accuracy, as the total flux is easily figured.

Magnets for handling billets, rails, etc., laid in piles are, as a rule, operated in pairs. Such material usually comes in 30-ft. lengths and is most conveniently handled by two magnets placed about 18 or 20 ft. apart on a balancing bar to which the crane hook is attached.

Magnets for handling pig-iron, scrap, etc., present the greatest difficulties in design. Such magnets are expected to handle a wide range of material, varying in form, in magnetic permeability, and often encountered in irregular piles; hence the reluctance of the magnetic circuit, and consequently the total flux will vary with each lift. This makes accurate calculation of total flux almost impossible and experience absolutely essential to the production of a thoroughly good magnet.

By a "good magnet" is meant one which will lift, in proportion to its own weight, the greatest possible amount of material. The weight of the magnet itself must be considered as dead weight, and the aim of the manufacturer,

CUTLER-HAMMER MAGNET HANDLING STEEL STAMPINGS.

therefore, is to construct a magnet that shall combine the minimum of weight with the maximum of lifting capacity.

The engineers of the Cutler-Hammer Clutch Co., of Milwaukee, who for more than half a score of years have devoted themselves to problems involving electric and magnetic control, have after several years of experiment perfected a lifting magnet which, it is claimed, marks a distinct step in advance in this industry. The magnet recently placed on the market by this company embodies new features not possessed by any other lifting mag-

net, and under competitive tests has developed a lifting capacity considerably in excess of any magnet now on the market.

In the design of the Cutler-Hammer magnet the magnetic attraction of the inner pole has been purposely made stronger than that of the outer pole. The practical effect of this concentration of the magnetic flux on the inner pole is that in handling iron pigs or similar material the various pieces constituting the load are released by the outer pole first, when the current is switched off, and are drawn towards the center of the magnet by the superior attraction of the inner pole, thus enabling the operator to deposit the load within an area scarcely exceeding in radius the diameter of the magnet itself.

Every prospective purchaser of a lifting magnet wishes to know in advance the amount of current the magnet requires, so as to intelligently calculate the saving that may be reasonably expected in handling material with this labor-saving device.

The following data obtained during a test of a 52-in. Cutler-Hammer magnet at the plant of the Youngstown (Ohio) Sheet & Tube Works throws light on this point:

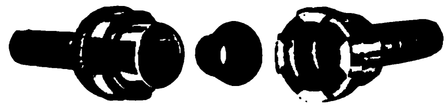
Total weight of pig-iron unloaded from steel gondola..........109,350 lbs.
Weight of average lift..............739 lbs.
Number of trips required to empty gondola 139
Current on magnet............1 hr. 15 min.
Current off magnet.................50 min.
Total time consumed ....2 hrs. 5 min.
Current required....30 amperes at 220 volts

From the foregoing figures the cost of operation is easily figured, assuming cost of current to be 3 cts. per kilowatt-hour, which is much in excess of cost of current in large commercial plants.

Thirty amperes at 220 volts corresponds to a power consumption of 6.6 [illegible] watts, which was required for 1 hr. 15 min. This gives a total power consumption of 8.25 kilowatt-hours, which [illegible] cts. per kw. [illegible] gives a [illegible]

A NOVEL HOSE COUPLING.

[illegible] a new [illegible] overcome [illegible] namely, leak- [illegible] a while. In [illegible] halves of a "Dall[illegible] coupling and the gasket used. The gasket is of a rubber composition, which is not affected by oil or gasoline, and is held in the female half of the coupling by a flange around the larger end, fitting into a recess. Upon connecting the coupling, the tapering end of the gasket enters the conical opening in the male part and fits closely therein. When pressure comes on the coupling, this tapered end of the



DALLETT HOSE COUPLING.

gasket is expanded against the walls of the conical opening, making a tight joint, which the pressure of air or steam only makes tighter. As soon as the pressure is relieved, the gasket is again loose, and, no matter how long a coupling may remain connected, the gasket will not adhere to the metal and be torn in taking the coupling apart. The gasket can not fall out, and be lost when the coupling is disconnected, and a new gasket can be inserted in a few seconds when necessary. The coupling is made of hard bronze composition. It has no projecting parts to catch when the hose is trailing along the ground. This useful device is manufactured by the Thos. H. Dallett Co., Philadelphia.

NEW FEATURES IN HIGH-SPEED ENGINE CONSTRUCTION.

Two features worthy of mention have recently been adopted by the Harrisburg Foundry & Machine Co., of Harrisburg, Pa., in the construction of their line of high-speed engines.

One of these is a system of automatic lubrication, in which a pure mineral oil is poured into the engine frame so that the outside of the crank disk comes in contact with the oil. As soon as the engine starts, the disk throws oil from this reservoir back upon the guides and crosshead, Fig. 1, and also into a trough [illegible] across the inside of the oil hood which [illegible]. From this trough a short tube [illegible] to a point over the main bearing, [illegible] it flows in a constant stream always visible to the engineer.

From the bearing, the oil works inward toward the crank disk and finds its way into an eccentric groove in the face of the disk next to the bearing, by which groove it is thrown outward through an oil passage to a hole in [illegible] of the crankpin. From this hollow

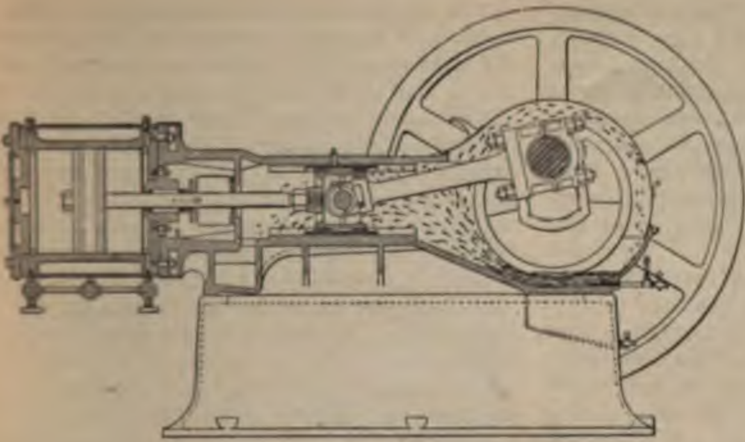


Fig. 1.

Fig. 2.

DETAILS OF THE OILING SYSTEM OF THE FLEMING ENGINE.

the oil is thrown through a passage to the crankpin bearing and works out from this back to the oil reservoir. It will be seen that this is a centrifugal oil-pumping system without valves or pump passages to become clogged.

The second feature is the solid cast crank-pin, which is shown in Fig. 2. The pin and crank disk are cast together from a combined steel and iron and are turned on the same face plate, thus making certain that the pin is square with the disk and avoiding any possibility of breakage. The ends are finished with fillets of large radius so that there are no square corners to become sources of weakness. Also, with this style of construction it is possible to use a larger pin than when the pin is inserted, so that the wearing surface is increased and the pressure per square inch greatly diminished. Casting the pin hollow results in lightness, strength and a certainty of freedom from defect as well as giving an oil reservoir.

THE UNIVERSAL HYDRAULIC JACK.

The original hydraulic jack was invented by Richard Dudgeon in 1849, and patented by him in 1851, and since that time the modifications and improvements which have been made are mainly in the method of lowering the jack or adapting it to meet special conditions.

The demand for large jacks in the last decade of three or four times the former power was met by increasing the size of the ordinary types of jacks, without attempting to attain a better result through departure from the recognized standards. Users of jacks have therefore been obliged to content themselves with unnecessarily heavy, cumbersome and slow hydraulic jacks. But in order to adequately meet the conditions now imposed a new form of hydraulic jack has lately been invented and is being made by Richard Dudgeon, Broome and Columbia streets, New York. This new type of hydraulic jack is known as the Universal, because of its advantages, and to distinguish it from other types.

THE DUDGEON DOUBLE-PUMP UNIVERSAL HYDRAULIC JACK.

The Universal jack is light, easily handled, operated and controlled.

This jack is intended to withstand rough usage, and has but few parts to get out of order.

It has double pumps, so that if the load is light, or if the ram must be extended some distance before the strain commences, the two pumps can be used together until the strain becomes excessive, when one pump is thrown out by a turn of the handle. Reversing the operation throws both pumps into service again. The jack can be operated either vertically or horizontally, and with the lever working at any angle.

Lowering can be done either by the lever or by the valve handle, and the jack can be furnished to lower by either method alone. If the jack is desired to lower by the lever only, a special cam giving less throw is furnished; if it is desired to lower it by the valve handle only, the lowering pin is removed. But one pressure valve for both pumping and lowering is required.

An important feature of this jack is that the valve handle always shows the position of the valves. It can turn only in a half-circle in either releasing the auxiliary pump or lowering, and the operator always knows whether one pump, two pumps, or the lowering device is in use.

This jack is lowered by the operator pressing all the valves from their seats by the lever or valve handle, as he may desire, since all the valves are combined in a single valve chamber in a superimposed position, and all are forced off their seats together, the liquid being allowed to flow around the valves from the pressure chamber into the reservoir. This double pump jack has a greatly reduced number of parts, and the superimposed valves and pistons are new and desirable features as any valve or either piston may fail and the jack [illegible]

This jack has the [illegible] [illegible] valve [illegible] [illegible] the valves and allowing the flow of the [illegible]

[illegible]

[illegible] is the [illegible] chamber, [illegible]

The operation of the jack may be clearly understood from the illustration, which shows a double pump jack. With both pumps in action a jack of 30 tons maximum capacity will lift a load of 15 tons at the rate of one inch in every six strokes. With only the lower pump working 30 tons may be raised one inch with twelve strokes. The pumps are controlled by a valve handle that may also be used for lowering the jack, although the jack may be lowered in the usual way by the operating lever when reversed in its socket. When the valve handle is in the position shown in the engraving the cam at the end of its shaft allows the push tube to be held up by the coiled spring at its lower end, so that all the valves are free to seat. The single pump action is obtained when the valve handle is turned down to a vertical position, which movement revolves the cam sufficiently to unseat the upper valve, so that the upper piston ceases to work, the liquid displaced by it simply surging back and forth through the open suction valve. With this condition only the two lower valves are used, the middle one being the suction valve for the lower piston. Turning the valve handle to the opposite horizontal position unseats all of the valves, allowing the ram to descend by its own weight. To lower the jack by means of the operating lever the arm is depressed until a pin projecting from the lower side of the piston head encounters the top of the push tube, when it performs the same office as the cam on the valve handle shaft. This type of jack therefore comprises the advantages of the single and double pump jacks, since it contains the lifting advantages of two pumps with the simple lowering arrangement of the single pump jack.

DEVICE FOR CLEANING WATER MAINS.

The two illustrations given herewith show a device which has been successfully used for cleaning the interior surface of an 8-in. cast-iron water main about [illegible] ft. long, in [illegible]

This main has been in use for over 14 years, and for the last third of that period the [illegible] has been gradually growing [illegible] and the formation [illegible]

[illegible] sections of from 400 to [illegible] of the line and fitted with [illegible] connections, as shown. A [illegible] was then inserted carrying a flexible wire cable and the water turned on, forc-

"GO-DEVIL" EMERGING FROM SECTION, BRINGING WITH IT A FLEXIBLE WIRE CABLE FOR PULLING CLEANER THROUGH PIPE.

ing the "Go-Devil" through the section. A ⅝-in. wire cable was then connected to the wire drawn through by the "Go-Devil" and pulled back through the pipe by means of a small winch. This was fastened to the cleaner, which was then dragged through the pipe by means of a four-man winch, breaking the scale and tubercles off, the flow of water

INSERTING CLEANER IN SECTION.

washing the latter out of the pipe ahead of the cleaner. The internal diameter of the pipe was enlarged ½ in. by the cleaning, and the flow of water increased 121%.

TRADE CATALOGUES AND PAMPHLETS.

ACETYLENE SAFETY STORAGE SYSTEM. —The Commercial Acetylene Co., 80 Broadway, New York. Three folders, each 8¼ × 10 ins.; pp. 4; illustrated.

Two of these folders are supplements to the catalogue of the company, one dealing with the method used for converting the Pintsch lamp, and the other giving directions for applying locomotive headlight equipments. The third folder gives half-tone reproductions of photographs showing wrecks of cars, etc., which show that the safety devices employed are successful in preventing explosions which would ordinarily be expected to result.

CONCRETE MIXER.—Koehring Machine Co., Milwaukee, Wis. Paper; 6 × 9¼ ins.; pp. 8; illustrated.

Describes the Koehring mixer, which is of the combination drum and trough type. The sand and cement are first mixed dry in the drum, and the water and stone are added in the trough, in which runs a shaft fitted with paddles.

ECONOMICAL MACHINERY FOR THE COAL MINE.—Ingersoll-Rand Company, 11 Broadway, New York. Form 53A. Paper; 3¼ × 5½ ins.; pp. 24; 15 illustrations.

This neat and handy leaflet gives much information concerning the various machines for use in coal mining, which are manufactured by this company. Ten entirely distinct lines of apparatus are shown, which are quite up to date and are claimed to yield the highest efficiency in their respective classes.

ELECTRIC CRANE CONTROLLERS.—The Cutler-Hammer Mfg. Co., Milwaukee, Wis. Paper; 3⅝ × 8 ins.; pp. 32; illustrated.

This booklet sets forth the principal features which are peculiar to the Cutler-Hammer apparatus.

ELECTRIC MOTORS.—Sprague Electric Co., New York. Bulletins Nos. 108, 229, 230 and 231. Paper; 8 × 10½ ins.; pp. 8, 74, 20 and 8 resp.; illustrated.

No. 108 describes an electric dynamometer built by this company for the purpose of testing gasoline engines, and also suitable for measuring the power from any mechanical source. It differs from the well-known Prony brake in that the reaction of friction is replaced by an electromagnetic reaction. These dynamometers are manufactured in sizes ranging from 10 up to 100 HP.

No. 229 is a handsomely gotten-up pamphlet, profusely illustrated with half-tones show-

ing the numerous applications of the Sprague direct-current motor equipments to printing machinery and allied apparatus.

No. 230 is a reprint of an article which appeared in the "Electrical World," describing the application of the company's products to factory work in one of the most perfectly equipped machine shops in the country.

No. 231 deals with direct-current motor equipments for use in connection with single and double magazine Mergenthaler linotype machines.

ELECTROLYSIS PREVENTION.—H. W. Johns-Manville Co., New York. 8-page folder, $3\frac{1}{2} \times 6\frac{1}{4}$ ins.; illustrated.

This circular describes asbestos paper covering treated with waterproofing material, which is manufactured for use in protecting pipes against electrolysis. The paper is $\frac{1}{4}$ to $\frac{3}{8}$ in. thick and is supplied in 3-ft. sections. Special sleeves are provided for sleeve couplings.

RAILWAY SIGNAL RELAY.—The Union Switch & Signal Co., Swissvale, Pa. Paper, 6×9 ins.; pp. 4; illustrated.

This folder supplements the 1902 catalogue of the company, and describes the No. 7-C relay, superseding the No. 4-C, the Type X and the Model 3 relays.

WATER TUBE BOILERS.—D. D. Flanner Boiler Co., Toledo, Ohio. Paper; 6×9 ins.; pp. 16; illustrated.

This catalogue is devoted to describing briefly the features of the Park water-tube boiler. The most notable consist of divided headers and the use of four steam delivery tubes from each header to the steam drum which is of the cross type. Each header [illegible] with the accompanying tubes is suspended [illegible] end, allowing for [illegible] [illegible]

STEAM ENGINES.—Wisconsin Engine Co., Corliss, Wis. Paper; $10 \times 6\frac{3}{4}$ ins.; pp. 57; illustrated.

This catalogue illustrates and describes the company's high-duty Corliss engines (simple, cross-compound and tandem-compound) for operating electric generators, rolling-mills, air-compressors and other heavy machinery. The special features are described and illustrated separately. Tables of sizes and dimensions are given.

TOBIN BRONZE.—The Ansonia Brass & Copper Co., 99 John St., New York City. Paper; 4×7 ins.; pp. 34; illustrated.

This booklet contains results of tests for corrosion resistance, crushing, torsional, tensile and transverse strengths. Weights and directions for manipulation, are also included.

TURBINE PUMPS.—Tacony Iron Co., Land Title Bldg., Philadelphia, Pa. Catalogue 3. Paper; 6×9 ins.; pp. 32; illustrated.

The advantages of turbine pumps are set forth in general in this catalogue, with directions for installation and operation. Numerous forms of turbine pumps as made by this firm are briefly described and curves of performance are given.

WELDING BY THE THERMIT PROCESS.—Goldschmidt Thermit Co., 90 West St., New York. Two pamphlets. Paper; 6×9 ins.; pp. 12 and 24 resp.; illustrated.

The smaller of these pamphlets is devoted to an explanation of the methods used in butt-welding wrought iron and steel pipes and rods by means of the Thermit process. The larger pamphlet has been prepared for the purpose of furnishing specific directions covering the various applications of Thermit for welding, repairing castings, etc. Numerous illustrations are given, including burning a new jaw on a heavy shear, repairing motor frames and locomotive cylinders, and welding broken dredge buckets in the field.

We wish [illegible] readers to the alteration in the make-up [illegible] the change in shape of the [illegible] an even printer's "form" [illegible] who wished to clip the items [illegible] magazine, however, it has been [illegible] pages in an even form, so that, in order to [illegible] readers who desire to make [illegible] we have backed up the pages with advertising. This will [illegible] desired items without impairing the value of others.

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American Journal of Science.
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Implement Age.
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Inland Architect.
Insurance Engineering.
International Marine Engineering.
Inventive Age.
Iron Age.—See Adv. opposite.
Iron Trade Review.
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Journal of U. S. Artillery.
Journal of Worcester Polytechnic Institute
Judicious Advertising.
Machinery.
Marine Review.
Metal Industry.
Metal Worker, Plumber and Steam Fitter.
Mines and Minerals.—See Adv.
Mining and Scientific Press.
Mining Reporter.
Mining World.
Modern Machinery.
Moody's Magazine.
Motor.
Motor Age.
Motor Boat.
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Power and Transmission.
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Railway Age.—See Adv. opposite.
Railway and Engineering Review.
Railway and Locomotive Engineering.
Railway and Marine World.
Railway Engineering.
Railway Master Mechanic.
Roadmaster and Foreman.—Se Adv. opposite.
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Selling Magazine.
Sibley Journal of Engineering.—See Adv.
Southern Machinery.
Stevens Institute Indicator.

Stone.
Street Railway Journal.—See Adv.
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The Aeroplane Experiments of M. Louis Blerlot. Capt. Ferber. Sc. Am Sup—Sept. 14, 07. 7 figs. 2300 w. 20c. A résumé of what has been accomplished to date in France with aeroplanes of various types, including that invented by Prof. Langley.

Cylinder Temperatures and Pressures.

Register of Cylinder Temperatures and Pressures. Automobile Sept. 12, 07. 2 figs. 600 w. 20c. Translated from "La Vie Automobile," by Charles B. Hayward.

Design.

Some Trends in Modern Automobile Design. Victor Loughead. Motor Age—Aug. 29, 07. 1 fig. 3800 w. 20c. V.—Discusses the probability of motor cars of the future being gearless and clutchless.

Materials of Construction.

Bearing Metals for Automobile Use. Thomas J. Fay. Automobile—Sept. 19, 07. 1400 w. 20c. Extract from "Part V.," "Materials for Automobile Construction."

Malleable Castings for Motor Cars.—II. P. I. Giron. Mech Wld—Sept. 13, 07. 3 figs. 1200 w. 20c.

Structural Bronze for Automobile Parts. Thomas J. Fay. Automobile—Sept. 5, 07. 7700 w. 20c. Extract from "Part Four," "Materials for Automobile Construction."

Motor Efficiency.

Effect of Size on the Thermal Efficiency of Motors. H. L. Callendar. Mech. Wld—Sept. 20, 07. 3700 w. 20c. Paper read before the Institution of Automobile Engineers.

Motor Street Sprinklers.

Motor Street Sprinkling Wagons. A. Heller. Z V D I—Sept. 7, 07. 15 figs. 1000 w. 60c. Gives details of gas power sprinklers used in Germany and Italy.

Springs.

Motor Car Springs as they Should Be. J. G. Rumney. Motor Age—Sept. 12, 07. 2 figs. 3000 w. 20c. Paper read at the Buffalo meeting of the Society of Automobile Engineers.

Upkeep of Motor Car.

What Does it Cost to Own an Automobile? Automobile—Sept. 5, 07. 500 w. 20c.

Weight vs. Wind Resistances.

Weight Versus Wind Resistances. Motor —Sept. 3, 07. 1 fig. 700 w. 40c.

CIVIL ENGINEERING

BRIDGES.

Bridge Failure in France.

Failure of Railway Bridge at Ponts de Ce. J. Phizey. Genie Civil—Sept. 14, 07. 9 figs. 5000 w. 60c. Gives details of a catastrophe due to failure of floor of a bridge over the Loire, France.

Deflections and Oscillations, Recorder for.

Apparatus for Recording Deflections and Oscillations of Metallic Bridges. Génie Civil. Aug 31, 07. 5 figs. 1200 w. 60c.

Design.

Determination of the Line of Pressure in an Elastic Arch. E. Haimovici. Beton u Eisen Sept. 7, 07. 5 figs. 1500 w. $[illegible]

Stresses in Lattice Bars of Built Columns. Thomas H. Johnson. Eng News—Sept. [illegible] 07. 2000 w. 20c.

The Proportioning of Steel Railway Bridge Members. Henry S. [illegible] Eng News—Sept. 19, 07. 1 diagram. [illegible] 20c. From a paper published in the Proceedings of the Engineers' Society of Western Penn. July, 1907.

Drawbridges.

Electrically-Operated Swing Bridge at Duisburg-Ruhrort Harbor. Messrs. Ottman Lobell. Zeit d Bau—Sept. 7, 07. 9 figs. 2000 w. 40c. Descriptive, with details of bearings and rollers.

Renewal of Chicago River Drawbridge of the Chicago Northwestern. Ry Age—Sept. 6, 07. 2 figs. 600 w. 20c.

The Substructure of the Dearborn Street Bridge, Chicago. Eng Rec—Sept. 14, 07. [illegible] figs. 8200 w. 20c. Describes foundations for a rolling-lift bascule bridge over the Chicago River.

Quebec Bridge.

The Collapse of the Quebec Bridge. Frank W. Skinner. Engg—Sept. 20, 07. 5 figs. [illegible] w. 40c.

The Erection of the South Cantilever Arm of the Quebec Bridge. Eng Rec—Sept. 28, [illegible] figs. 2000 w. 20c. Gives statistics not previously published and also references to the many articles on the subject printed in earlier numbers of the journal.

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The Fall of the Quebec Bridge. Eng News—Sept. 12, 07. 5 figs. 4000 w. 20c. Gives data on the defective bridge chord, loadings, strain diagrams of anchor arms, etc.

The Fall of the Quebec Cantilever Bridge. Eng News—Sept. 5, 07. 20 figs. 10,000 w. 20c. Exhaustive description of the collapse of this bridge, written after inspection of the wreckage.

The Greatest Engineering Disaster. Eng News—Sept. 5, 07. 3700 w. 20c. Editorial survey of the possible causes of the Quebec Bridge collapse, and deductions from an inspection of the wreck.

The Quebec Bridge. Engr—Sept. 6, 07. 17 figs. 5600 w. 20c. Describes features of construction.

The Quebec Bridge. Frank W. Skinner. Engg—Sept. 13, 07. 7 figs. 7600 w. 40c. First installment of an extended description of the design and construction of this important work.

The Quebec Bridge. Frank W. Skinner. Engg—Sept. 20, 07. 72 figs. 5400 w. 40c. Details of members and connections.

The Quebec Bridge Disaster. Engg—Sept. 6, 07. 4 figs. 3900 w. 40c. A descriptive article, including a hypothesis of the cause of the wreck.

The Quebec Bridge Failure: Our Deficient Knowledge of the Strength of Large Columns. Eng News—Sept. 12, 07. 1 fig. 4000 w. 20c. Editorial discussion of the subject.

The Suspended Falsework of the Cantilever Arms of the Quebec Bridge. Eng Rec—Sept. 21, 07. 8 figs. 3000 w. 20c.

Reinforced Concrete Bridges.

Methods and Costs of Constructing Concrete Highway Bridges by Day Labor in Green County, Iowa. Engg-Contr—Sept. 4, 07. 200 w. 20c. From a paper read at the Iowa Cement Users' Convention by Henry Haag and D. E. Donovan.

New Bridge of Reinforced Concrete—Wabash Railroad. Ry Age—Sept. 6, 07. 5 figs. 1200 w. 20c. Describes a bridge crossing the Sangamon River, 3.6 miles east of Decatur, Ill.

The New Stanford Bridge, Worcestershire. Engg—Aug. 23, 07. 9 figs. 1600 w. 40c. Describes the largest reinforced concrete bridge in England.

Strengthening Old Bridge.

Strengthening an Old Lattice-Girder Bridge. George J. Davis, Jr. Eng Rec—Sept. 28, 07. 11 figs. 2100 w. 20c. Describes methods employed on an 8-span, white pine sextuple Warren truss bridge, at Grand Rapids, Mich.

Suspension Bridge.

Link Suspension Foot-Bridge over the Aare, Berne, Switzerland. F. Ackerman. Schw Bau—Aug. 31, 07. 7 figs. 700 w. 40c.

Viaducts.

Double Tracking a Steel Viaduct with a Concrete Arch Structure. A. D. Williams, Jr. Conc Engg—Sept. 1, 07. 7 figs. 1800 w. 20c.

Reinforced Concrete Viaduct-Richmond & Chesapeake Bay Railway. Ry Age—Sept. 27, 07. 9 figs. 2200 w. 20c. Describes an example of reinforced-concrete construction substantially different from the usual type.

Sixth Street Viaduct, Kansas City, Mo. Ry Engg & Maint-of-Way—Sept., 07. 7 figs. 2500 w. 20c.

The Erection of Las Vacas Viaduct. Eng Rec—Sept. 14, 07. 3 figs. 2200 w. 20c. Describes methods used on a 743-ft. track viaduct on the Guatemala Ry.

The New Steel Viaduct Between Kansas City, Mo., and Kansas City, Kan. Eng News—Sept. 26, 07. 17 figs. 7400 w. 20c. Describes an important and recently completed steel structure 8,400 ft. long.

EARTHWORK, ROCK EXCAVATION, ETC.

Breaking Boulders.

The Cost of Breaking Boulders by Means of a Derrick and a Drop Hammer. Engg-Contr—Sept. 11, 07. 1100 w. 20c.

Dumping Wagon, Strength of.

Strength Tests of a Contractor's Dumping Wagon. Eng News—Sept. 19, 07. 3 figs. 2100 w. 20c.

Excavating.

A Stripping Excavator with a Conveyor to Form the Waste Bank. Eng News—Sept. 12, 07. 1 fig. 1600 w. 20c.

Machinery and Methods for the Excavation of Sky-Scraper Foundations. T. Kennard Thomson. Eng Mag—Oct., 07. 23 figs. 7000 w. 40c.

Four Examples of the Cost of Excavating Earth with the Wheeled Scraper. Engg-Contr—Sept, 25, 07. 1100 w. 20c.

The Cost of Excavating Earth with Wheeled Scrapers. Engg-Contr—Sept. 4, 07. 1000 w. 20c.

Overhaul.

The Calculation of Overhaul. Can Cem & Conc Rev—Sept., 07. 1 dia. 700 w. 20c.

The Calculation of Overhaul. Can Engr—Sept. 6, 07. 2 figs. 2000 w. 20c. Gives diagrams and tables for use in railroad construction work.

Rock Drill, Improved.

A New Departure in Rock Drills. Engr—Aug. 30, 07. 5 figs. 1100 w. 40c. Describes a detachable bit for use in drills, the object of which is to save time otherwise lost by trips to repair shops.

"Swelling" of Rock.

The "Swelling" of Rock Upon Excavation. Engg-Contr—Sept. 25, 07. 1000 w. 20c.

ENGINEERING CONSTRUCTION.

Buildings.

A Combined Underpinning and Sheeting Job. Eng Rec—Sept. 7, 07. 1 fig. 2000 w. 20c. Describes work of this nature on a new six-story steel cage bank building at Murray St. and Broadway, New York.

A Reinforced Concrete Boot Factory, Leicester, England. Conc & Constr Engg—Sept., 07. 15 figs. 700 w. 40c.

A Reinforced Concrete Cathedral in Manila. Conc & Constr Engg—Sept., 07. 10 figs. 1100 w. 40c.

A Reinforced Concrete Church. A. M. Ferry. Conc Engg—Sept. 1, 07. 9 figs. 1800 w. 20c. Describes a very successful application of reinforced concrete construction made in the Unity Church, Oak Park, Ill.

Concrete Shops and Car Houses at Nashville. St Ry Jl—Sept. 14, 07. 8 figs. 2500 w. 20c.

Moving the Old Montauk Theater, Brooklyn. Eng News—Sept. 5, 07. 1100 w. 20c.

The Erection of the 612-Ft. Singer Building. Sc Am—Sept. 7, 07. 3 figs. 2200 w. 20c.

The McNulty Building, New York. Eng Rec—Sept. 14, 07. 2 figs. 1400 w. 20c. Describes a new 10-story and basement reinforced concrete building.

Underpinning Adjacent to the Silversmiths' Building, New York. Eng Rec—Sept. 28, 07. 3100 w. 20c. Describes methods used in shoring and transferring loads to new footings, etc.

Calculation of Frameworks.

The Calculation of Rigid Frameworks. O. Lemptrecht. Beton u Eisen—Sept., 07. 4 figs. 2000 w. $1.

Chimney.

Fall of a 150-Ft. Reinforced Tile and Concrete Chimney at La Crosse, Wis. Eng News—Sept. 5, 07. 7 figs. 2800 w. 20c.

Dams.

Completion of the Cross River Dam, Croton Water-Works System. Eng Rec—Sept. 14, 07. 4 figs. 3400 w. 20c.

The San Roque Dam, Argentine Republic. H. Mattern. Zeit d Bau—Aug. 31, 07. 9 figs. 1000 w. 40c.

The Stresses in Masonry Dams. Engg—Sept. 13, 07. 2100 w. 40c. Discusses theories recently advanced by Prof. Karl Pearson and other writers.

Fireproofing.

Strength and Fire Protection of Brick Walls. Alfred Stone. Ins Engg—Sept., 07. 3000 w. 40c. Discusses the carrying capacity of brick walls, their stiffness or ability to stand upright and resist wind pressure and vibration and the fire resistance of brick walls of certain thicknesses.

Terra Cotta Fireproofing. A. S. Atkinson. Ins Engg—Sept., 07. 5 figs. 3800 w. 40c.

Floating Derrick.

60-Ton Floating Derrick, Suez Canal. Ch. Dantin. Génie Civil—Aug. 31, 07. 18 figs. 2500 w. 60c.

Lighthouse.

The Fastnet Rock Lighthouse. Engr—Sept. 13, 07. 15 figs. 3900 w. 40c. Gives details of the methods employed in erection.

Reinforced-Concrete Construction.

Analytical and Graphical Methods for Use on Reinforced-Concrete Beam Sections. R. Pokormy. Zeit Oest Ing U Arch—Sept. 6, 07. 8 figs. 5000 w. 60c.

Continuity in Reinforced Beams and Slabs. Eng Rec—Sept. 28, 07. 1300 w. 20c.

Faults of Reinforced Concrete Design and Construction. H. F. Porter. Conc Engg—Sept. 1, 07. 3100 w. 20c.

Load Tests of a Reinforced-Concrete Conduit. Schw Bau—Sept. 7, 07. 5 figs. 1000 w. 60c.

Reinforced Concrete. Ernest McCullough-Cem Era—Sept., 07. 2 figs. 5700 w. 20c.

Tests of Concrete and Reinforced-Concrete Columns. Prof. Arthur N. Talbot. Conc Engg—Sept. 1, 07. 9 figs. 2400 w. 20c.

The Danger of Using Rusty Iron in Reinforced Concrete. Am Arch—Sept. 14, 07. 500 w. 60c.

The Historical Evolution of Reinforced Concrete in Austria. Dr. Ludwig Hess—Conc & Constr Engg—Sept., 07. 7 figs. 3500 w. 40c.

The Logical Use of Reinforced Concrete In Building Construction. A. Jordahl. Conc Engg—Sept. 1, 07. 2 figs. 2800 w. 20c. Concluded.

The Mushroom System of Reinforced-Concrete Building Construction. A. S. Malcolmson. Engg-Contr—Sept. 4, 07. 4 figs. 2800 w. 20c. The essential feature of this new construction is the formation of a so-called mushroom at the top of each column, by extending its reinforcing rods, laterally, some four feet or more out into the slab in a radial direction and supporting on these, ring rods, which, in turn, carry the lighter reinforcement for the slab construction.

Roofs, Graphic Statics of.

Roofs. Ry Engr—Sept., 07. 6 figs. 2200 w. 40c. III—Graphic Statics.

Steel Work, Cleaning and Painting.

Cleaning Steel Work by Sand Blast and Painting by Compressed Air. De Witt C. Webb. Eng News—Sept. 18, 07. 1300 w. 30c.

Structural Steel Design, Literature of.

Literature of Structural Steel Designing. Harry Gwinner. Am Mach—Sept. 12, 07. 800 w. 20c.

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A Method of Tunneling High Railroad Embankments for Culverts. Eng Rec—Sept. 7, 07. 3 figs. 1500 w. 20c.

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Construction of the Second Simplon Tunnel. Schw Bau—Sept. 7, 07. 4 figs. 2500 w. 40c.

Costs and Methods of Construction of Tunnel for Water Pipes under Mystic River, Boston, Mass. Caleb Mills Saville—Eng News Sept. 26, 07. 1 fig. 5000 w. 20c.

Subaqueous Tunnel at Detroit. Ry & Loco Engg Sept., 07. 4 figs. 2300 w. 20s. Describes Mich. Central twin-tube tunnel at Detroit.

The C. P. R. Tunnel near Palliser, B. C. Ry & Mar Wld—Sept., 07. 4 figs. 4500 w. 40c.

The Present Condition of the Battery Tunnel Under the East River (New York). Eng News—Sept. 19, 07. 2000 w. 20c.

The Selby Hill Tunnel of the Twin City Rapid Transit Company. El Ry Rev—Sept. 28, 07. 9 figs. 1800 w. 20c.

The Selby Hill Street Railway Tunnel, St. Paul, Minn. Eng Rec Sept. 21, 07. 6 figs. 5300 w. 20c.

Underground Workings in New York City. H. T. Hildage. Eng Mag—Oct., 07. 17 figs. 8000 w. 40c.

Water and Sewer Mains.

A 7-Ft. Steel Pipe Line at St. Louis. Eng Rec Sept 7, 07. 1 fig. 1600 w. 20c. Describes a pipe flow line 19,634 ft. long, now being added to the city supply system.

Method of Constructing a High-Pressure Concrete Pipe Water Main at Swansea, England. Engg-Contr Sept. 18, 07. 3 figs. [illegible]00 w. 20c.

Methods and Cost of Constructing a Reinforced Concrete Pipe for Carrying Water Under Pressure. Chester W. Smith. Engg-Contr Sep. 11, 07. 6 figs. 3300 w. Sept. 18. 1 fig. 2500 w. Each 20c. Paper read before the American Society of Civil Engineers and [illegible] Proceedings for [illegible]

[illegible] Sewer [illegible]

IRRIGATION AND DRAINAGE.

[illegible]

Irrigation and Drainage Problem in Stanislaus Co., Cal. C. S. Abbott. Cal Jl Technology—Aug., 07. 2 figs. 180 w. 20c.

Methods and Cost of Lining an Irrigation Canal with Cobble Stones and Plaster. Engg-Contr—Sept. 11, 07. 800 w. 20c.

MATERIALS.

Cement and Concrete.

Cast Stone. W. P. Butler. Cem Era—Sept., 07. 1500 w. 20c. Concluded.

Effect of Steam Curing on the Crushing Strength of Concrete. Eng News—Sept. [illegible], 07. 2 figs. 4300 w. 20c. Gives results of a series of tests recently conducted at the Lewis Institute, Chicago.

Electricity for Cement Plants. L. B. Porter. Eng Rec—Sept. 21, 07. 4 figs. 2500 w. 20c. Paper read before the Association of American Portland Cement Manufacturers.

Essential Features of Concrete Blocks. Fred. W. Hagloch. Cem Era—Sept., 07. 1 fig. 1000 w. 20c.

Experiments on the Strength of Slag Concrete. G. Kauffman. Beton u Eisen—Sept. 7, 07. 2 figs. 2500 w. $1.

Mortar and Concrete Mixtures. William Challoner. Engr—Sept. 6, 07. 2 figs. 5000 w. 40c. Considers the subject of lime and cement mortars upon a scientific and practical basis, with the assistance gained by a close examination of the methods that have secured the permanency of the mortar found in ancient structures.

Notes on the Le Chatelier Test. W. L. Gadd. Engr—Sept. 13, 07. 3800 w. 40c. Discusses this test for the constancy of volume of Portland Cement.

Some Avoidable Causes of Variation in Cement Testing. Ernest B. M'Cready. Concrete—Sept. 14, 07. 2200 w. 20c. Read before the Am. Soc. for Testing Materials.

The Disintegration of Portland Cement Mortar. E. Maynard. Cem Age—Sept., 07. [illegible] w. 20c. Paper presented to the Brussels Congress.

The Laws of Proportioning Concrete. Charles F. Marsh. Conc & Constr Engg—Sept. 07. 1 dia. 5000 w. 40c. A summary of the work of Messrs. Fuller & Thompson with comments.

The Permeability of Concrete and Methods of Waterproofing. Richard H. Gaines. Eng News Sept. 26, 07. 4800 w. 20c. Gives the results of an investigation now being carried on by the New York Board of Water Supply.

The [illegible] and Control of Cement [illegible] S. Larned. Conc Engg—S[illegible] w. 20c.

[illegible] British Standard Specification [illegible] Cement. Conc & Constr [illegible] w. 40c.

The Testing of Clay and Concrete Pipes. Mun Engg—Oct., 07. 2600 w. 40c. An abstract of parts of a report of Burchartz and Stock, of the royal building material testing department in Gross-Lichterfelde.

Iron.

The Corrosion of Iron: Rusting. Eng News—Sept. 26, 07. 5000 w. 20c. Discusses the various theories of corrosion, including the electrolytic theory recently advanced.

Testing Laboratory, U. S. Government.

The Equipment and Work of the U. S. Government Concrete Testing Laboratory at St. Louis, Mo. Richard L. Humphrey. Engg-Contr—Sept. 25, 07. 2 figs. 1700 w. 20c.

The Structural Materials Testing Laboratories at St. Louis. Richard L. Humphrey. Conc Engg—Sept. 15, 07. 6 figs. 2900 w. 20c.

Timber.

The Advance of Eucalyptus in California. Cal Jl Technology—Aug., 07. 3200 w. 20c.

The Strength of Wood as Influenced by Moisture. Harry D. Tiemann. Roadmaster & F—Sept., 07. 4 figs. 3800 w. 20c.

Timber Forestation in California. H. A. Crafts. Am Carp & Bldr—Sept., 07. 2 figs. 2000 w. 40c. Describes the work being done in that state to replenish the fast disappearing forests.

RIVERS, CANALS, HARBORS.

Appalachian Streams, Southern.

Southern Appalachian Streams. Charles F. Waddell. Jl of Franklin Inst—Sept., 07. 9 figs. 10,000 w. 60c.

Barge Canal, New York State.

The New York State Barge Canal. Ind Mag—Sept., 07. 13 figs. 10,000 w. 20c. Gives an extended description of the construction work on this canal.

Dock Pumping Plant.

Pumping Plant for the New South Dock, Cardiff. Engg—Sept. 6, 07. 4 figs. 3900 w. 40c.

Foreshore Protection.

A New Method of Foreshore Protection of Sea Coasts. J. R. R. de Muralt. Beton u Eisen—Sept., 07. 10 figs. 2500 w. 1.

River Waves.

Progressive and Stationary Waves in Rivers. Vaughan Cornish. Engg—Aug. 23, 07. 3 figs. 7000 w. Sept. 16, 9 figs. 5700 w. Each 40c.

Wharves.

Reinforced Concrete Wharves and Quays. W. Noble Twelvetrees. Conc & Constr Engg—Sept., 07. 4 figs. 2800 w. 40c. III.—Docks and Quays on the Clyde.

SURVEYING AND MENSURATION.

Accuracy in Mensuration.

On Accuracy in Mensuration and Calculation. Engr—Sept. 6, 07. 4500 w. 40 c. Discusses the practical requirements of accuracy in various classes of work.

Planimeter.

The Planimeter. Frank J. Gray. Surv—Sept. 6, 07. 3 figs. 3300 w. Sept. 13. 13 figs. 4800 w. Sept. 20. 22 figs. 2500 w. Each 40c. A series of articles describing the various types of planimeters and their use.

Railway Spiral Tables.

A Unit Table for Talbot's Spiral. Eng Rec—Sept. 7, 07. 2 figs. 4800 w. 20c. Compiled by G. A. Kyle, Jr., for the use of this easement curve on the Pacific extension of the C. M. & St. P. Railway, west of Butte.

ECONOMICS

Apprentice System.

A National Apprentice System. New York [illegible] Am Engr and R [illegible] Sept [illegible] figs [illegible] w. [illegible]

British Patent Law, New.

The New Patent Act. [illegible] Sept [illegible] [illegible] w. [illegible] the new [illegible] Patent Act which takes [illegible]

Cost Accounting.

A [illegible] [illegible] cost keeping.

[illegible] Discusses [illegible] for [illegible] of expenses.

Keeping Account of Supplies. Matt W. [illegible] Min & Sc Press—Sept. 14, 07. [illegible] w. [illegible]

Engineering Business.

Starting an Engineering Business. Sydney F. Walker. Prac Engr—Aug. 30, 07. [illegible] w. [illegible] Continuation of serial; discusses stock-keeping.

Engineering Education.

[illegible] Workshops. Chas. P. [illegible] Am Mach—Sept. [illegible] 07. 3000 w. [illegible]

[illegible] Courses in Engineering at the University of Cincinnati. Herman Schneider. Am Mach—Sept. 12, 07. 2200 w. [illegible] Paper read before the Society for the Promotion of Engineering Education.

Direct-Current Generators.

A Method of Determining the Leading Dimensions of Large and High-Speed Continuous-Current Dynamos. H. M. Hobart and A. S. Ellis. El Rev (Lond)—Sept. 13, 07. 2 figs. 1700 w. Sept. 20, 07. 2000 w. Each 40c.

Three-Wire Direct Current Generators. H. T. McCormick. El Rev—Sept. 28, 07. 2 figs. 1000 w. 20c. Paper read at the annual convention of the Canadian Electrical Association, Montreal, Sept. 11-13.

Synchronizing.

Synchronizing. Paul MacGahan and H. W. Young. Elec Jl—Sept., 07. 7 figs. 6300 w. 20c. Describes various devices employed for this purpose.

Transformers.

Abnormal Primary Current and Secondary Voltage on Placing a Transformer in Circuit. Trygve Jensen. El Wld—Sept. 14, 07. 1000 w. 20c.

Outline of the Characteristics of Constant Potential Transformers. George A. Burnham. El Wld—Sept. 7, 07. 6 figs. 2800 w. 20c.

LIGHTING.

Arc Lamps.

Recent Advances in Artificial Lighting: Arc and Vacuum Tube Electric Lamps. Eng News—Sept. 12, 07. 16 figs. 8000 w. 20c. Discusses at length flaming and metallic-arc lamps, mercury vapor lamps and the Moore vacuum tube light.

Recent Developments in Metallic Flame Arc Lamps. G. Brewer Griffin. El Rev—Sept. 14, 07. [illegible] figs. 2800 w. 20c.

The Flaming Arc Lamp. J. H. Hallberg. El Rev—Sept. 14, 07. [illegible] w. 20c.

Germany.

[illegible] Lighting in Germany. Dr. [illegible] [illegible] El Rev [illegible] w. [illegible]

Illumination.

[illegible]

[illegible]

[illegible]

of a committee before the Ohio Electric Light Association, held at Toledo, Ohio, Aug. 20-21-22.

The Economy of the Tungsten Lamp. Alfred A. Wohlauer. El Wld—Sept. 7, 07. 2 figs. 8100 w. 20c.

The Helion Light. Walter G. Clark. El Rev—Sept. 14, 07. 1 fig. 2000 w. 20c.

The Nernst Glower and the Present Status of the Nernst Lamp. Otto Foell. El Rev—Sept. 14, 07. 9 figs. 4600 w. 20c.

The Recent Incandescent Lamp Developments and Their Significance. Francis W. Willcox. El Rev—Sept. 14, 07. 8 figs. 4000 w. 20c.

The Sirius Colloid Lamp. Paul McJunkin. El Rev—Sept. 14, 07. 2 figs. 1000 w. 20c.

Mercury Vapor Lamp.

The Mercury Vapor Lamp. Percy H. Thomas. El Rev—Sept. 14, 07. 4 figs. 4500 w. 20c.

The Mercury Vapor Lamp as a Factor in Electricity Supply Development. El Rev (Lond)—Aug. 23, 07. 4 figs. 2300 w. 40c.

Moore Light.

The Moore Light and Illuminating Engineering. D. McFarlan Moore. El Rev—Sept. 14, 07. 2 figs. 2200 w. 20c.

Photometry.

Coefficients of Diffused Reflection. Dr. Louis Bell. Prog Age—Sept. 16, 07. 1000 w. 20c. Paper read before the Illuminating Engineering Society, Boston, July 31.

Photometric Units. Preston S. Millar. El Rev—Sept. 14, 07. 1700 w. 20c.

Photometry at the Bureau of Standards, Washington, D. C. Dr. Edward P. Hyde. El Rev—Sept. 14, 07. 4 figs. 2800 w. 20c.

PLANTS AND CENTRAL STATIONS.

Best Power for Small Plants.

What is the Best Form of Power for Stations of Five Hundred Kilowatts Capacity or Less? F. C. Caldwell. W Elecn—Sept. [illegible] w. 20c. Paper read before [illegible] Electric Light Association, Toledo, [illegible]

Central Station Principles.

[illegible] Station Light, Heat and Power [illegible] Harrison. Central Station [illegible] w. 20c.

Combined Gas and Electric Plants.

[illegible] Working of Electric Power Stations [illegible] Gas Works. Dr. Alfred Graden- [illegible] Sept. 14, 07. 7 figs. 1000 [illegible] a combination of this [illegible] near Berlin.

[illegible] Lamps on Station Income.

[illegible] Efficiency Lamps on [illegible] Income. El Rev—Sept. [illegible] A symposium from [illegible] the United States and

Selling Electricity.

Methods of Charging for Electric Motive Power [illegible] Aug. [illegible] the American [illegible] Electric Light Association [illegible]

[illegible]

TELEGRAPHY AND TELEPHONY

Telephony.

[illegible]

Wireless Telegraphy.

[illegible]

TESTS AND MEASUREMENTS

Condenser Testing.

[illegible]

Transformer Testing.

Method of Testing Transformers. [illegible] L'Eclairage Elec—Aug. 17, '07. [illegible] figs. [illegible]

Notes on Transformer Testing. [illegible] figs. [illegible] abstract of a paper presented at the convention of the American Institute of Electrical Engineers, Niagara Falls, June [illegible]

Wattmeter Standards.

[illegible] Secondary Wattmeter Standards. [illegible] El [illegible]—Sept. [illegible]

TRANSMISSION, DISTRIBUTION, CONTROL

High-Tension Transmissions.

[illegible] Power Transmission in [illegible] Describes an interesting [illegible] phase power transmission in [illegible] construction, utilizing the [illegible]

[illegible] the Highest Working [illegible] Grand [illegible]

[illegible] Power Transmission. [illegible]

[illegible] Transmission Line. [illegible] Elec [illegible]

[illegible] Transmission [illegible] installed with [illegible] interesting details.

[illegible]

[illegible] High-Tension.

[illegible] C. [illegible] the annual convention [illegible] Electrical Association [illegible]

[illegible]

[illegible] Line Construction. [illegible] paper read before the [illegible] Association [illegible]

[illegible] Construction. A. B. [illegible]—Sept., '07. 6 figs. [illegible] extended article on the

Sag in Wire Spans.

Tension and Sag in Wire Spans. Harold Pender. El Wld—Sept. 28, 07. 2 figs. 1900 w. 20c. Gives charts for determining without arithmetical computation the variation of the tension and sag in copper wire spans with the temperature and resultant load on the wire.

Polyphase Circuits, Notation for.

Notation for Polyphase Circuits. Charles H. Porter. Elec Jl—Sept., 07. 7 figs. 3200 w. 20c. Describes a system based essentially on lettering every junction and terminal on the diagram of connections, and on the use of two subscripts with every symbol of current or electro-motive force or vector representing them.

Wattmeter Switchboard.

Switchboards of Wattmeters and Watt-Hour Meters for Measuring Power and Energy in Polyphase Circuits. Paul MacGahan. El Wld—Sept. 14, 07. 10 figs. 3100 w. 20c.

MISCELLANEOUS.

Electrical Agricultural Installation.

An Electrical Agricultural Installation in Saxony. D. S. Paxton. El Engg—Aug. 29, 07. 8 figs. 1600 w. 40c. Describes an installation comprising fixed and portable motors for use in every branch of farming work.

Insurance and Inspection of Apparatus.

Insurance and Inspection of Electrical Machinery. Mech Engr—Sept. 7, 07. 4 figs. 5300 w. 40c. Extracts from report by Mr. Michael Longridge, to the British Boiler Insurance Company.

Lightning Conductors.

Lightning Conductors. Frank Broadbent. El Rev—Aug. 23, 07. 1600 w. 40c.

Plunger Magnets, Design of.

The Design of Plunger Magnets. C. P. Nachod. El Wld. 3 figs. 1200 w. 20c. Gives formulas, curves and data for designing magnets for specific work.

INDUSTRIAL TECHNOLOGY

Acetylene.

Acetylene Illumination. Ins Engg—Sept., 07. 4400 w. 40c. A paper submitted to the International Acetylene Association, showing acetylene's place among illuminants.

Acetylene Lighting. Nelson Goodyear. Prog. Age—Sept. 2, 07. 8 figs. 3000 w. 20c. Paper read before the Illuminating Engineering Society, Boston, July 31.

Automatic Acetylene Generator for Chemical Laboratories. Randolph Bolling. E & M Jl—Aug. 31, 07. 1400 w. 20c.

Alcohol Lamp.

Tests of Alcohol Lamps and Stoves. S. M. Woodward and B. P. Fleming. Sc Am Sup—Sept. 21, 07. 11 figs. 4000 w. 20c. Gives comparisons and measurements, operations, power and fuel consumed.

Alkali Manufacture.

Alkali as a Field of Industry. Eustace Carey. Brit Tr Rev Sept. 2, 07. 4300 w. 40c. Important address by the president at the annual meeting of the Society of Chemical Industry.

Cotton Goods, Bleaching, Etc.

Bleaching, Mercerizing and Dyeing of Cotton Goods. F. J. G. Beltzer. Génie Civil—Sept. 14, 07. 4 figs. 3000 w. 60c.

Electrolytic Disinfectant, Manufacture of.

Manufacture of Electrolytic Disinfectant at Poplar, London. W Elecn Sept. 21, 07. 2 figs. 1300 w. 20c.

Explosives, Manufacture of.

Modern Explosives. H. Schmerber. Génie Civil—Aug. 31, 07. 16 figs. 3000 w. Sept. 7. 2200 w. Sept. 14. 2200 w. Each 60c. Serial taking up the theory of explosives and methods of their manufacture.

Fixation of Nitrogen.

The Fixation of Nitrogen. Norman Whitehouse. Electrochem & Met Ind—Sept., 07. 2800 w. 40c. A paper read before the London section of the Society of Chemical Industry; from the Journal of the Society, July 15.

Gas Analysis.

Rapid and Accurate Gas Analysis. Edwin Barnhart. Electrochem & Met Ind—Sept., 07. 6 figs. 2200 w. 40c.

Automatic Gas Analysis. Prog Age—Oct. 1, 07. 7 figs. 1700 w. 20c. Describes an automatic apparatus of simple construction wherewith a volumetric analysis of a gaseous mixture may be made either quantitatively, qualitatively, or both.

Illuminating Gas.

Classification of Distribution Data and Correspondence. Walton Forstall. Prog Age Sept. [illegible], 07. 3700 w. 20c. Gives a decimal classification for use by gas engineers.

The Coke Conveying Plant at the Paris Gas Works: Experiments with a Water Jet Conveyor. Am Gas Lt Jl—Sept. 16, 07. 5 figs. 3600 w. 20c. From the "Journal of Gas Lighting."

Ten Minutes A Month is all that is necessary to learn what articles of specific interest in your line have appeared during the previous month in the technical periodicals of America and Europe. Technical Literature in each issue gives a classified descriptive listing of all articles of importance appearing in the current technical press, all brought down to the first of the month of issue. Consult it.

Distant Lighting of Inverted Burners. G. Kern. Prog Age—Oct. 1, 07. 2900 w. 20c.

Rigid and Other Joints. Am Gas Lt Jl—Sept. 2, 07. 7 figs. 3700 w. 20c. From the "Gas World."

The Inverted Gas Light. T. J. Litle, Jr. Prog Age—Sept. 2, 07. 10 figs. 2300 w. 20c. Paper read before the Illuminating Engineering Society, Boston, July 31.

The World's Largest Gas Holder. Prog Age—Sept. 16, 07. 17 figs. 2200 w. Describes a 15,000,000-cu. ft. gas holder recently erected in Astoria, L. I.

Vertical Retorts and Chamber Distillation in Germany. Prog Age—Oct. 1, 07. 3600 w. 20c.

Water Gas (II.). H. Dicke. Stahl und Eisen—Aug. 21, 07. 4000 w. 60c.

Paper, Durability of.

The Durability of Paper. Paper Making—Sept., 07. 700 w. 40c.

MARINE ENGINEERING

Battleships.

The Size of Battleships as a Function of Their Speed. J. A. Normand. Int Mar Engg—Oct., 07. 1 fig. 5600 w. 40c. From Proceedings of the United States Naval Institute.

Cleaning Marine Boilers.

Cleaning Marine Boilers. Lieut. H. C. Dinger, U. S. N. Int Mar Engg—Oct., 07. 5 figs. 3600 w. 40c.

Early Steam Navigation.

William Symington and the Beginnings of Steam Navigation. Robert Cochrane. Case Mag—Oct., 07. 9 figs. 6000 w. 40c.

Electric Equipment.

The Electrical Installation of the Royal Mail Steam Ship "Adriatic." El Engr—Sept. 19, 07. 4 figs. 1100 w. 40c.

Light Vessels.

Single Screw Steam Light Vessels. Int. Mar Engg—Oct., 07. 10 figs. 1900 w. 40c.

Marine Turbines.

Design and Arrangement of Marine Turbines and Propellers. Ernest N. Janson. Mech Engr—Sept. 14, 07. 4400 w. 40c. Paper read before the American Society of Naval Engineers.

Mooring-Buoy.

Mooring-Buoy for the "Lusitania" and "Mauretania." Engg—Aug. 23, 07. 2 figs. 500 w. 40c.

Navigation.

Navigation by Celestial Observation. Stephen P. M. Tasker. Int Mar Engg—Oct., 07. 7 figs. 1000 w. 40c.

Screw Propeller.

The Screw Propeller (XIV.). A. E. Seaton. Mar Engr & Nav Arch—Sept. 1, 07. 1 fig. 3500 w. 40c.

Train-Ferry Steamers.

Train-Ferry Steamer "Lucia Carbo" for the Entre Rios Railway. Engg—Sept. 6, 07. 7 figs. 1000 w. 40c.

MECHANICAL ENGINEERING

AIR MACHINERY.

Compressed Air.

Compressed Air and the Kinetic Theory of Gases. J. H. Hart. Power—Oct., 07. 1900 w. 40c.

Strength of Tanks.

Strength of Air Pressure Tanks. Ira J. Owen. Ins Engg—Sept., 07. 10 figs. 2900 w. 40c. Gives formulae and specifications for the construction of steel sprinkler pressure tanks and discusses defective design, poor construction, decay and mismanagement as the causes of explosion.

FOUNDING.

Liquid Fuel for Foundry Use.

Liquid Fuel and Its Application in the Foundry. G. B. Waterhouse. Met Ind—Sept., 07. 4 figs. 4200 w. 20c.

Machine-Molded Gear Teeth.

Machine-Molded Teeth on Large Cast Gears. Am Mach—Sept. 12, 07. 9 figs. 3000 w. 20c. Shows how the teeth of gears are machine-molded from a simple tooth block and also illustrates some large herring-bone gears.

Malleable Castings.

Malleable Castings—II. E. L. Rhead. Mech Engr—Aug. 31, 07. 3700 w. 40c.

Heat Losses from Buildings.

Methods of Estimating Heat Losses from Buildings. Charles L. Hubbard. Htg & Vent Mag—Sept., 07. 2800 w. 20c.

Hot Air Heating.

Hot Blast Heating. Charles L. Hubbard. Dom Engg—Sept. 7, 07. 2 figs. 2600 w. Sept. 21. 1 fig. 1300 w. Each 20c. XII. Relations Between Volume, Pressure and Power. XIII. Horse-Power Required for Fans.

Hot-Water Heating.

High Boilers in Water Heating. A. T. Hoyt. Dom Engg—Sept. 27, 07. 2 figs. 1700 w. 20c.

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As a general rule, of course, the more ret a newspaper commands from its readers more respect they have for the advertising t. A bulletin posted in a disreputable ter does not tend to enhance the reputay of the concern using it."—New York Editorial

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Ads" move in a mysterious way heir wonders to perform.—"The Silent Partner."

Formula for Pipe Sizes in Hot-Water Heating. Oliver H. Schlemmer. Htg & Vent Mag—Sept., 07. 3 figs. 8000 w. 20c. Paper read at the semi-annual meeting of the American Society of Heating and Ventilating Engineers, Milwaukee, Wis., July 18-19.

Vacuum Heating System.

The Vacuum Heating System in the Godfrey Block, Grand Rapids. Eng Rec—Sept. 14, 07. 3 figs. 1800 w. 20c. Describes plant possessing several unusual features.

Ventilation.

Air and Its Relation to Vital Energy. S. H. Woodbridge. Dom Engg—Sept. 21, 07. 2300 w. 20c. Conclusion.

The Ventilation of Factories. Engg—Aug. 23, 07. 2 figs. 2200 w. 40c.

HOISTING AND HANDLING MACHINERY.

Conveyors.

Modern Development in the Art of Conveying Materials. W. R. Hurlburt. Ind Mag—Sept., 07. 3 figs. 4200 w. 20c.

Cranes, Under-Carriages for.

The Design of Under-Carriages for Jib Cranes. E. G. Fiegehen. Prac Engr (Lond)—Aug. 30, 07. 7 figs. 2800 w. 40c.

Electro-Magnets for Lifting.

Electro-Magnets for Lifting and Handling Materials. Charles R. Benjamin. Cass Mag—Oct., 07. 12 figs. 3500 w. 40c. Illustrated description of successful types of lifting magnets.

Lifting Magnets and Their Numerous Industrial Applications. Ind Wld—Sept. 9, 07. 7 figs. 3500 w. 20c.

The Electric Magnet in Practical Use. Ind Mag—Sept., 07. 9 figs. 1300 w. 20c.

Elevators.

A Positively-Controlled, High-Speed Electric Elevator. Eng News—Sept. 26, 07. 1 fig. 1900 w. 20c.

Notes on Elevators. E. R. Carichoff. El Rev—Sept. 21, 07. 1 fig. 2500 w. 20c. A comparison of hydraulic and electric elevators, favoring the latter.

The Electric Elevator Equipment for a Tall Office Building. Eng Rec—Sept. 21, 07. 3 figs. 2000 w. 20c. Describes installation of the 18-story office building at No. 1 Wall Street, New York City.

The Hydraulic Elevator. X.—William Baxter, Jr. Power—Oct. 17. 12 figs. 3700 w. 40c. Discusses the construction of traveling-sheave frames, the strengthening of foundations and supports, and the avoidance of piston and cylinder friction.

Mine Hoisting Plant.

A New Mine Plant in Germany. B. F. Hurschauer. El Rev—Sept. 28, 07. 5 figs. 1900 w. 20c. Describes modern hoisting equipment installed at the Thiederhall mines, near Brunswick.

HYDRAULIC POWER PLANTS.

Centrifugal Pumps.

Centrifugal Pumps. E. F. Doty. Engr—Oct. 1, 07. 2 figs. 3000 w. 20c. I. Some historical and theoretical considerations.

Engine-Driven Centrifugal Pumps: Their Capacities, Limitations and Duties. Ry & Engg Rev—Sept. 7, 07. 1 fig. 1500 w. 20c.

Hydro-Electric Development.

Hydro-Electric Power Development. Wm. Kennedy. Can El News—Sept., 07. 1 fig. 1600 w. 20c. Discusses subject with special reference to long distance power transmission and some turbines of large unit capacity, operating under high heads of water.

Hydro-Electric Plants.

A Water Power Station for the Supply of Lucerne. El Engr—Sept. 19, 07. 15 figs. 4000 w. 40c.

Some Hydraulic Features of Kern River Plant No. 1. W. Elecn—Sept. 7, '07. 3300 w. 20c.

The Hydro-Electric Development of the Great Northern Power Co. Eng Rec—Sept. 7, 07. 9 figs. 6100 w. Sept. 14. 8 figs. 4300 w. Each 20c. Describes an extensive project on the St. Louis River, near Duluth, Minn.

The Hydro-Electric Plant at Kakabeka Falls, Ont. Can El News—Sept., 07. 11 figs. 4600 w. 20c.

The Hydro-Electric Plant of the Canadian Niagara Power Company. Can El News—Sept., 07. 5 figs. 5000 w. 20c.

The Hydro-Electric Plant of the McCall Ferry Power Co. Eng. Rec.—Sept. 21, 07. 13 figs. 10,000 w. 20c.

The McCall Ferry Hydro-Electric Power Plant on the Susquehanna River. Eng News—Sept. 12, 07. 19 figs. 12,300 w. 20c. Extended description of a 100,000-HP. project in Pennsylvania.

The Kaministiquia River Water-Power Developments. El Wld—Sept. 14, 07. 7 figs. 2300 w. 20c. A 14,000-HP. installation, 18 miles from Ft. William, Ont.

The New Hydro-Electric Plant of the Sherbrooke Power, Light & Heat Company. Can El News—Sept., 07. 3 figs. 1900 w. 20c.

The Plans of the Bar Harbor and Union River Power Company. El Wld—Sept. 21, 07. 4 figs. 1700 w. 20c.

Hydraulics.

Experiments with Submerged Tubes 4 ft. Square. C. B. Stewart. Eng Rec—Sept. 28, 07. 4 figs. 2500 w. 20c. Discusses the loss of head, resulting from the flow of water through submerged gates, tubes and orifices of considerable size and various forms of entrance.

Flow of Water Carrying Sand in Suspension. F. K. Blue. Eng & Min Jl—Sept. 21, 07. 3200 w. 20c. An experimental study of factors which influence the relation between the velocity required and the proportion of sand in suspension.

The Effect of Changes in Canal Cross-Sections upon Rate of Flow. F. W. Hanna. Eng. News Sept. 26, 07. 3000 w. 20c.

The Velocity of Water in Conduits. Engg Aug. 23, 07. 1400 w. 40c.

Governors.

Mechanical Details of the Governors of the Water Wheel Equipment of the Kern River Plant No. 1. Arnold Pfau. Am Mach—Sept 19, 07. 1 fig. 3200 w. 20c.

Pumps and Pumping Plants.

How to Set the Valves of a Duplex Pump. F. F. Nickel. Power Oct., 07. 8 figs. 1900 w. 10c. Gives simple directions with explanatory diagrams, including also the effect and treatment of the cross exhaust.

Mechanical Tests of Pumps and Pumping Plants in California. J. N. Le Conte and C. E. Tait. Jl of El P & Gas Aug. 31, 07. 2 figs. 8000 w. 20c. From Bulletin U. S. Dept. Agr., Office of Experiment Stations.

Modern Pumping and Hydraulic Machinery XVI Edward Butler. Mech Engr—Aug 24, 07. 6 figs 3900 w. XVII. Sept. 21 7 figs. 2700 w. Each 40c.

Most Efficient Cylinder Ratio in Direct-Acting Pumps. F. F. Nickel. Mech Wld—Sept 13, 07 8 figs. 1800 w. 20c.

Turbines.

Notes on the Governing of Hydraulic Turbines Robert S Ball Engg Aug. 23, 07. 11 figs 5600 w 40c. Paper read before Section G of the British Association at Leicester August 7

The Wear of Turbines Special Study of the Edges of Corrosion J. Dalemont ... Aug 24 ... figs ... w Aug 31 6 figs 2200 w Each 40c

Two-Stage Compound Turbine ...

Water Power.

INTERNAL COMBUSTION ENGINES.

Gas Engines. I. A. Naegel. Z V D I—Sept. 7, 1907. 10 figs. 7500 w. Sept. 14. 15 figs. 9,000 w. Each 60c.

Gas Engine Breakdowns.

Gas Engine Breakdowns. Michael Longridge. Mech Engr—Aug. 31, 07. 9 figs. 5000 w. 40c. Gives the author's observations on gas-engine breakdowns in his annual report to the British Engine and Boiler Insurance Company.

Gas Engine Development.

Modern Gas Engine Development in Europe and America. Jl of El P & Gas—Sept. 7, 07. 2 figs. 3400 w. 20c.

Some European Tendencies in Gas Engine Manufacturing—Oswald H. Haenssgen. Gas Engine—Sept. 5, 07. 1 fig. 5000 w. 20c.

Gas Producers.

Modern Power Gas Producer Practice and Applications. Horace Allen. Prac. Engr (Lond)—Aug. 30, 07. 2300 w. 40c. Continued. The Blast Furnace as a Gas Producer.

Speed Regulation.

Speed Regulation of Internal Combustion Engines. Engr—Oct. 1, 07. 1500 w. 20c. Discusses its relation to thermal efficiency under varying loads.

MACHINE PARTS.

Ball Bearings.

Investigations on Hardened Steel Balls. R Stribeck. Z V D I—Sept. 14, 07. 9 figs. ... w 60c. First article giving results of tests on hardened steel, especially for balls for use in bearings.

The Design and Use of Ball Bearings.—Henry Hess. Am Mach—Sept. 5, 07. 39 figs ... w. 20c. Installment of A. S. M. E. paper showing and explaining details of design and many typical ball-bearing constructions for radial thrust and angular loads.

Belting.

Notes on Belting. Wm. O Webber. Engr ... w 20c.

Cams for Screw Machines.

... of Automatic Screw Machines ... and F. A. Stanley. ... 15 figs. 4800 w. ... angles of Pratt & ... calculation or ... feeds per turn of

... Wld—Sept. ..., 07. 5 ... methods for use in

... Strength of Curved ... Z V D I—Sept. 7, 07. ... formulas for ... for bearings.

What Some People Say of Technical Literature

EDWARD A SOUTHWORTH, Dept. of Public Works, Honolulu.—I have enjoyed every issue of Technical Literature, which covers a field greater than any other publication in its class at the present date.

ROBERT GRIER COOKE, Publisher, New York.—Let me congratulate you upon your creditable publication.

DOMINGO A. USINA, New York City.—Allow me to congratulate you. I hope you may have a long success. Technical Literature is exactly the thing for a patent attorney who could not possibly keep up with the literature of all engineering branches separately.

LINN WHITE, Engineer, South Park Commissioners, Chicago.—I am much surprised at the number of interesting articles upon various subjects. You have multum in parvo.

Lathe Beds.

Machine Tool Design. J. T. Nicolson. Engr (Lond)—Aug. 30, 07. 5 figs. 5000 w. Sept. 13. 2200 w. Each 40c. XL. and XLI. Lathe Beds. Gives many examples of English and American sections with diagrams and formulas for principal dimensions.

Machine Screws.

Standard Proportions of Machine Screw Heads. Am. Mach—Sept. 12, 07. 4 figs. 300 w. 20c. Gives corrected formulas to replace those in the Proc. A. S. M. E. which contain a number of errors.

Speed-Changing Mechanisms.

A Four Speed Change-gear Device. B. F. Landis. Am Mach—Sept. 26, 07. 5 figs. 1500 w. 20c.

Speeds and Feeds in Geometric Progression. John Parker. Am Mach—Sept. 26, 07. 7 figs. 4100 w. 20c. Shows how speeds and feeds for machine tools are calculated in geometric progression by logarithms and gives typical examples.

MATERIALS.

Alloys, Preparation of.

Alloys. A. Humboldt Sexton. Mech Engr—Sept. 14, 07. 3400 w. 40c. XXIII. Preparation of Alloys.

High-Speed Tool Steel.

Service Test of High-Speed Tool Steels. L. S & M S R R. Am Engr & R R Jl—Sept. 07. 700 w. 40c.

Vanadium in Steel.

The Effect of Vanadium in Steel. F. T. [illegible]. [illegible] Rev—Sept. 26, 07. 2000 w. [illegible]

MECHANICS.

Beams, Strength of.

The Strength of Beams. [illegible] Kidne. [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible] 1900 w. [illegible]

Shear.

The Behavior of Materials under Pure Shear Stress. E. Prenss. Stahl u Eisen—Aug. 21, 07. 3 figs. 1100 w. 60c.

Stress, Measurement of.

The Work of Deformation as a Measure of Strain. Rud. Girtler. Zeit Oest Ing u Arch—Sept. 13, 07. 9 figs. 5500 w. 60c. A mathematical study with illustrations of the effect of stresses on several varieties of glass.

Testing Machines.

New Machines and Methods for Testing Metals. P. Breuil. Rev de Mec—Sept., 07. 6 figs. 1300 w. $1.80. Continuation of article begun in April number.

METAL WORKING.

Annealing Furnace.

Side-Fired Furnaces for Annealing, etc. Walter J. May. Prac Engr (Lond.)—Aug. 30, 07. 5 figs. 1400 w. 40c.

Bevel Gear Cutter.

A French Machine for Cutting Bevel Gears. G. Eude. Am Mach—Sept. 5, 07. 10 figs. 3300 w. 20c. Describes a machine in which each tooth of the gear is milled at a single cut by means of a novel helicoidal cutter of superimposed pitches.

Boiler Parts, Layout of.

Layout of a Double Offset Pipe. C. Reynolds. Boiler Maker—Oct., 07. 1200 w. 20c.

Layout of a Taper Transit Piece. H. S. Jeffrey. Boiler Maker—Oct., 07. 19 figs. [illegible] w. 20c. Describes method used for a connection between two round cylinders, the taper being eccentric and one side a flat surface.

Boiler Tubes.

Manufacture of Boiler Tubes. F. N. [illegible] Ry & Engg Rev—Sept. 7, 07. 1900 w. [illegible] Paper read before the Richmond Railway Club.

Cutlery, Manufacture of.

Manufacture of Cutlery at Solingen. Mech [illegible] 2800 w. 40c. Report [illegible] Johnston, H. M. Inspector [illegible] the Sheffield district, on [illegible] methods adopted at Solingen, [illegible] of cutlery manufacture.

Dust Prevention in Grinding.

[illegible] of Dust Prevention in [illegible]. Samuel R. Bennett. [illegible] 1 fig. 2800 w. [illegible]

Flanging Press.

[illegible] Flanging Press. E. A. [illegible] Boiler Maker—Oct., 07. 5 figs. 1800 w. 20c. Describes work done by heavy press for boiler shop.

Forging.

Forging at the Collinwood Shops. L. S. & M. S. R. R. Am Engr & R R Jl—Sept., 07. 5 figs. 700 w. 40c.

Gaging System.

A New Swedish Combination Gaging System. E. A. Dixie. Am Mach—Sept. 19, 07. 17 figs. 4500 w. 20c. Describes system whereby 81 extremely accurate gages are used in combination and 80,000 different gage sizes varying by 0.0001 inch are obtained.

Cutters, Grinding.

Grinding Cutters for Rotary Planers. John Ridell. Am Mach—Sept. 26, 07. 4 figs. 1000 w. 20c.

Lapping.

Lapping. E. A. Johnson. Am Mach—Sept. 12, 07. 3 figs. 1900 w. 20c.

Milling.

A Relieving Attachment for the Milling Machine. Am Mach—Sept. 5, 07. 1 fig. 500 w. 20c.

Milling Attachments for the Lathe. Oscar E. Perrigo. Am Mach—Sept. 19, 07. 300 w. 20c.

Oxy-Acetylene Blowpipe.

The Oxy-Acetylene Blowpipe. Cecil Lightfoot. Ir Age—Sept. 19, 07. 2300 w. 20c. From a paper presented at the International Acetylene Association, July, 1907.

Plate Shear.

A Large German Hydraulic Plate Shear. Frank C. Perkins. Am Mach—Sept. 12, 07. 1 fig. 500 w. 20c. Describes a rolling-mill shear for shearing plates up to two inches in thickness and 14 feet in maximum breadth.

Soldering.

Experiments on Soldering. A. Lippmann. Elek Zeit—Aug. 25, 07. 4 figs. 5600 w. 40c. Sept. 5. 6 figs. 3300 w. 40c.

Experiments on Soldering. Adolph Lippmann. El Rev—Sept. 20, 07. 2 figs. 3600 w. 40c. Translated from the "Elektrotechnische Zeitschrift."

Test Indicator.

Toolmakers' Universal Test Indicator. J. D. Stryker. Am Mach—Sept. 19, 07. 9 figs. 1000 w. 20c.

Twist Drills.

The Making and Testing of Twist Drills. Fred H. Colvin. Am Mach—Sept. 26, 07. 18 figs. 6400 w. 20c. Describes the tools used, methods of testing and results obtained by the Cleveland Twist Drill Company, Cleveland, O.

REFRIGERATION.

Management of an Absorption Plant. W. S. Luckenbach. Cold Stor & I T Jl—Sept., 07. 2600 w. 40c.

Refrigerating Plant of Washington Brewing Company. Engr—Sept. 16, 07. 11 figs. 4300 w. 20c. Describes a practical plant designed for economical operation.

Overhauling the Ice System. J. C. Calhoun. Ice & Refrig—Sept., 07. 3000 w. 40c. Gives suggestions for repairing and operating the distilling and freezing end—cause of air lock—connecting filters—method of pulling tank, etc.

SHOPS AND BUILDINGS.

Cost of Producing Machine Parts.

Modern Machinery and Its Future Development. H. I. Brackenbury. Engr—Aug. 30, 07. 500 w. 40c. Discusses comparative cost of production of machine parts by engine, turret and automatic lathes, from an English standpoint of wages. Paper read at the British Association at Leicester.

Reinforced-Concrete Shops.

The New Manufacturing Plant of the George N. Pierce Co., Buffalo, N. Y. Howard S. Knowlton. Eng Rec—Sept. 7, 07. 13 figs. 5600 w. 20c. Describes a recently constructed reinforced-concrete plant for the manufacture of automobiles.

STEAM POWER PLANTS.

Ash Handling.

Ash Handling Plant, P. & L. E. R. R. Am Engr & R R Jl—Sept., 07. 7 figs. 900 w. 40c.

Barring Gears.

Electric Barring Gear for Large Engines. Engg—Sept. 13, 07. 5 figs. 1000 w. 40c. Describes device for turning fly-wheel shaft around to any desired position.

Blast Furnace Gas Fuel.

Determination of the Quantity and Heating Value of Waste Gases from Blast Furnaces. J. Von Ehrenwerth. Stahl u. Eisen —Sept. 4, 07. 900 w. 60c.

Boilers.

An English Boiler Improvement. Ir Age—Sept. 19, 07. 7 figs. 2800 w. 20c.

Cylindrical Boiler Furnaces. Boiler Maker—Oct., 07. 8 figs. 2800 w. 20c. Describes the development of modern suspension furnaces and methods of manufacture.

Methods of Obtaining Flexibility in Locomotive Fire Boxes. Boiler Maker—Oct., 07. 6 figs. 3300 w. 20c.

The Lining of Steam Boiler Furnaces. William Kavanagh. El Wld—Sept. 7, 07. 800 w. 20c.

The Nature of True Boiler Efficiency. W. T. Ray and Henry Kreisinger. Ir Age—Sept. 26, 07. 1 fig. 2200 w. 20c. Abstract of a paper read before the Western Society of Engineers, Chicago, Sept. 18.

The Rate of Heat Transmission in Steam Boilers. Ry Age—Sept. 27, 07. 1400 w. 20c.

Coal, Purchase of.

The Purchase of Coal Under Specifications. J. E. Woodwell. Mines & Min—Sept., 07. 7200 w. 40c. Discusses variations in heating values; adjusting payments; methods of sampling and analysis.

Cooling Towers.

The Capacity of Cooling Towers. Engr (Lond.)—Sept. 13, 07. 8 figs. 5000 w. 40c. Details and data regarding a number of different towers for cooling condensing water.

Economy of Small Anthracite Fuel.

The Economy of Small Anthracite Fuel. William D. Ennis. Eng Mag—Oct., 07. 18 figs. 2500 w. 40c.

Engine Breakdowns.

Engine Breakdowns and Their Lessons. Michael Longridge. Mech Engr—Aug. 24, 07. 17 figs. 6200 w. 40c.

Engine Foundations.

Steam-engine Foundations. R. T. Strohm. Power—Oct., 07. 2 figs. 2100 w. 40c.

Engine Valves.

Lubrication of Engine Valves. N. C. Hurst. Power—Oct., 07. 6 figs. 700 w. 40c.

Trick Valves. M. Hochwald. Z V D I—Aug. 31, 07. 12 figs. 1500 w. 60c.

Expansion of Steam.

The Action of Steam During Expansion. Fred R. Low. Power—Oct., 07. 5 figs. 3600 w. 40c. Shows how steam exerts pressure and how pressure varies with volume and temperature; also explains isothermal and adiabatic conditions.

Flue-Gas Analysis.

Flue-Gas Analysis: Its Value. Joseph W. Hays. Power—Oct., 07. 2200 w. 40c.

Fuel Testing Plant.

The Fuel Testing Plant of the Geological Survey. C. T. Wilkinson. Engg & Min Jl—Sept. 21, 07. 3 figs. 2500 w. 20c.

Indicators.

Combined Indicator Cards. Charles S. Lynch. Int Mar Engg—Oct., 07. 11 figs. 1200 w. 40c.

Improvements in Steam and Other Pressure Indicators. A. Wagener. Z V D I—Aug. 31, 07. 20 figs. 9000 w. 60c.

Indicator Practice. Engr—Sept. 16, 07. 14 figs. 6700 w. 20c.

Injectors.

Selecting an Injector. R. S. King. Engr—Oct. 1, 07. 3 figs. 700 w. 20c. States points to be noted in choosing an injector for the work to be accomplished.

The Injector and Some Requirements for Its Successful Operation. Paul E. Capraro. Engr—Oct. 1, 07. 10 figs. 2400 w. 20c.

Mechanical Stoking.

Mechanical Stoking. Elek u. Masch—Aug. 25, 07. 10 figs. 2500 w. 60c.

Oil Fuel.

Technical Aspects of Oil as Fuel. I. Franz Junge. Power—Oct., 07. 11 figs. 3900 w. 40c. Discusses liquid fuels, their treatment, and the formation of combustible mixtures, with regard to their application in power plants.

Power Plant.

The Power Plant of the Elgin National Watch Works. Eng Rec—Sept. 14, 07. 5 figs. 3700 w. 20c.

Pressure-Gages.

Remarks on Pressure-Gages. Engg—Aug. 30, 07. 2 figs. 11,200 w. 40c. Abstract from a memorandum by C. E. Strohmeyer, Chief Engineer, Manchester Steam Users' Association.

Safety Devices.

Hopkinson's Automatic "Explosion" Valve. Engg—Sept. 6, 07. 4 figs. 700 w. 40c. Describes a valve which automatically shuts off steam when a pipe bursts.

Modern Safety Devices for Prime Movers. C. C. Major. Power—Oct., 07. 13 figs. 4000 w. 40c. Describes the salient features of various engine-stop and speed-limit systems and their application.

Smoke Problem.

The Smoke Problem. David Townsend. Cass Mag—Oct., 07. 2900 w. 40c.

Speed Regulation.

The Speed Regulation of Steam Engines. Sterling H. Bunnell. Cass Mag—Oct., 07. 16 figs. 2700 w. 40c. Discusses the various forms of governors, beginning with the earliest types used.

Steam Turbine.

A New German Steam Turbine. Prac Engr (Lond)—Aug. 30, 07. 3 figs. 1400 w. 40c. Describes a steam turbine, having several novel features, recently brought out by Mr. J. A. Maffei of Munich.

Water Softener.

The Beisell Water Softener. Engg—Aug. 30, 07. 2 figs. 1900 w. 40c. Illustrated description of a new system.

WOODWORKING.

Flanged Pipe Patterns.

Patterns for Flanged Pipe Fittings. F. W. Barrows. Am Mach—Sept. 19, 07. 21 figs. 11,000 w. 20c.

METALLURGY

Blast Furnaces.

Improved Bell Valve for Regenerative Furnaces. H. Gille. Stahl u. Eisen—Sept. 11, 07. 4 figs. 1000 w. 60c.

The Blast Furnace. Horace Allen. Ir Tr Rev—Sept. 12, 07. 3400 w. 20c. VIII. The Utilization of Blast Furnace Gases.

FACSIMILE OF A COVER

Coke.

Electric Power in the Coal and Coke Industry. W. B. Spellmire. Ir Age—Sept. 12, 07. 1600 w. 20c.

The Manufacture of Coke Oven Gas. Ernest Bury. Min Wld—Aug. 31, 07. 1200 w. 20c. Abstract of a paper read before the British Institution of Gas Engineers.

Copper.

Copper Converters, Hydraulically Operated. G. B. Shipley. Min & Sc Press—Sept. 21, 07. 1 fig. 1900 w. 20c.

Influence of Iron in Copper Electrolysis. E. L. Larison. Eng & Min Jl—Sept. 7, 07. 1800 w. 20c.

Lead and Copper Smelting at Salt Lake. Walter R. Ingalls. Eng & Min Jl—Sept. 21, 07. 6 figs. 6600 w. Sept. 28. 5 figs. 5000 w. Each 20c.

Notes on Copper. A. Humboldt Sexton. Mech Engr—Sept. 7, 07. 7 figs. 3600 w. 40c. VII Continuous furnaces.

The Betts Electrolytic Process at Trail, B. C. A. G. Wolf. Min Wld—Aug. 31, 07. 1 fig. 2800 w. Sept. 14. 3100 w. Each 20c.

Electric Furnaces.

The Electrothermic Reduction of Iron Ores. Albert Green and Frank S. MacGregor. Electrochem & Met Ind—Sept., 07. 4 figs. 2100 w. 40c. This gives the results of an experimental investigation on the electrothermic reduction of iron ores containing titanium.

The Production of Pig Iron by Means of Electric Furnaces. B. Humann. Stahl u. Eisen—Aug. 28, 07. 12 figs. 4000 w. 60c. Describes the methods used by Heroult, Turnbull and others.

Electro Metallurgy.

Applied Electro Metallurgy Up to the End of 1906. John B. C. Kershaw. Eng Mag—Oct., 07. [illegible] 40c.

Gold.

[illegible]

Iron and Steel.

[illegible]

Lead.

[illegible]

Pyrometry.

High-Temperature Measurements. Thomas C. McKay. Cal Jl Technology—Aug., 07. 2 figs. 3700 w. 20c.

Optical Pyrometry. Dr. L. Holborn. Engg—Sept. 6, 07. 5000 w. 40c. Paper read before the British Association at Leicester, Aug. 7.

Roasting Furnace.

The McDougall Roasting Furnace. L. S. Austin. Min & Sc Press—Aug. 31, 07. 3 figs. 1400 w. 20c. Describes a type of furnace largely used in the inter-mountain states and mainly on ores containing 27 to 38% sulphur.

Slag.

Acid Open-Hearth Slag. W. M. Carr. Ir Tr Rev—Sept. 5, 07. 1000 w. 20c.

Iron Slag. Dr. Theodore Koller. Sc Am Sup—Sept. 21, 07. 2300 w. 20c. Describes the utilization of this waste product as slag wool, bricks and paving material.

Steel, Manufacture of.

The Manufacture of Steel and Wrought Iron in America. Bradley Stoughton. Eng Mag—Oct., 07. 21 figs. 8800 w. 40c. Treats the American steel industry in its metallurgical aspects.

Steel Works.

A New Straightening Machine for Rails and Structural Shapes. Stahl u. Eisen—Sept. 4, 07. 3 figs. 1500 w. 60c.

The Bethlehem Steel Company's New Plant. Ir Age—Sept. 26, 07. 3 figs. 6200 w. 20c. Describes the 28-in. rail mill and the 28-in. structural mill at South Bethlehem, Pa.

The Electric Power Equipment of the Burbacher Hütte. Frank C. Perkins. El Engr—Sept. 20, 07. 4 figs. 1300 w. 40c.

The Equipment of a Rolling Mill Laboratory. Aug. Kayser. Stahl u. Eisen—Sept. 11, 07. 2 figs. 3500 w. Sept. 18. 8 figs. [illegible] w. Each 60c.

The Forges and Mines of the Hungarian State. Engr Lond—Sept. 20, 07. 6 figs. [illegible] w. [illegible] Describes the principal steel works of the Hungarian State at Diosgyör.

Treatment of Waste Products.

[illegible] Treatment of Metalliferous [illegible] Parry. Min Jl—Aug. 31, 07. [illegible] IX Copper work, including [illegible] calciner.

Zinc.

[illegible] Plant of United States [illegible] Cañon City, Colorado. [illegible] Rep—Sept. 5, 07. 1100 [illegible] describes a modification of the [illegible] process which is used.

[illegible] Smelting at Granby, Missouri [illegible] E & M Jl—Aug. 31. [illegible] 20c. Discusses the ge[illegible] district, how the ores [illegible] and smelted, etc.

MINING ENGINEERING

Asbestos.

Asbestos. Its Mining, Preparation, Markets and Uses. E. Schaaf Regelman. Eng Mag—Oct., 07. 12 figs. 3500 w. 40c.

Borax.

The Borax Deposit of Salinas, near Arequipa, Peru. A. Jochamowitz. Min Jl—Aug. 24, 07. 1700 w. 40c.

Coal.

Bituminous Coal Washing. G. R. Delamater. Mines & Min—Sept., 07. 5 figs. 5500 w. 40c. Discusses the design of washery; equipment of plant; machines used for washing-coal. Continued from August.

Coal-Dust Explosions in Collieries. James Ashworth. Cass Mag—Oct., 07. 6 figs. 3000 w. 40c. Discusses the influence of water and steam on coal dust, as illustrated in the Wingate Grange Colliery Explosion.

Coal Mining in Michigan. Lee Fraser. E & M Jl—Sept. 28, 07. 2 figs. 1900 w. 20c.

Concrete Overcasts in Coal Mines. John H. Haertter. Eng & Min Jl—Sept. 7, 07. 6 figs. 3600 w. 20c. Discusses the use of overcasts in ventilating coal mines and methods of construction and advantages of concrete and steel over wood for the work.

Setting Timber in Anthracite Coal Mines. John H. Haertter. E & M Jl—Aug. 31, 07. 5 figs. 4700 w. 20c. States reasons why it would be impracticable to have a special timber corps instead of having the props placed by the miners.

Springhill, Nova Scotia, and Its Collieries. W. D. Matthews. Can Min Jl—Sept. 15, 07. 8 figs. 2600 w. 20c.

The Effect of Barometric Variation on the Outflow of Gas in Mines. W. H. Booth. E & M Jl—Aug. 31, 07. 1200 w. 20c.

The Unwatering of Mines in the Anthracite Region. R. V. Norris. Eng Mag—Oct., 07. 24 figs. 8000 w. 40c.

Westphalian Collieries. Can Min Jl—Sept. 1, 07. 4 figs. 3300 w. 20c.

Compressed Air in Mining.

Use of Compressed Air in Mining. Jos. H. Hart. Min Wld—Sept. 14, 07. 1700 w. 20c.

Copper.

Mining the Porphyry Ore of Bingham. Eng & Min Jl—Sept. 7, 07. 17 figs. 7400 w. 20c.

The Genesis of the Copper Deposits of Yerington, Nevada. E. P. Jennings. Can Min Jl—Sept. 1, 07. 1100 w. 20c.

The Ore Deposits of Copperopolis, California. John A. Reid. Min Wld—Sept. 21, 07. 2 figs. 2100 w. Sept. 28. 7 figs. 3200 w. Each 20c.

The Seven Devils and Snake River Districts. George D. Reid. E & M Jl—Aug. 31, 07. 4 figs. 2000 w. 20c. Details of a copper-bearing section in Washington Co., Idaho, and Baker Co., Ore.

Diamonds.

The Origin and Occurrences of the Diamond. T. W. E. David. Min Jl—Aug. 24, 07. 4000 w. 40c.

Economy in Mining.

Economy in Mining Operations. Thomas E. Lambert. Min & Sc Press—Sept. 14, 07. 1300 w. 20c.

Electrical Mining Machinery.

Fire and Explosion Proof Electrical Mining Machinery. El Rev (Lond.)—Sept. 20, 07. 3300 w. 40c.

Unique European Electric Mining Locomotives. Frank C. Perkins. Min Wld—Sept. 7, 07. 8 figs. 3400 w. 20c.

Explosives.

Permitted Explosives in British Coal Mines. James Ashworth. E & M Jl—Sept. 28, 07. 2000 w. 20c.

The Detection of Mercury in Explosives. W. A. Hargreaves and W. T. Rowe. Eng & Min Jl—Sept. 7, 07. 500 w. 20c. From Jl. Soc. Chem. Ind., July 30.

Fluorspar.

Fluorspar. Ernest F. Burchard. Min Rep—Sept. 26, 07. 1600 w. 20c. Advance chapter from "Mineral Resources of United States" calendar year 1906.

Gold.

Mining Conditions in South Africa. Mines & Min—Sept., 07. 7 figs. 10,000 w. 40c. Discusses the average value of ore; labor conditions; mining plants and methods and costs of mining and milling.

Some Gold and Tungsten Deposits of Boulder Co., Col. Waldemar Lindgren. Econ Geol—July-Aug., 07. 4000 w. 80c.

The Essential Data of Placer Investigations. J. P. Hutchins. E & M Jl—Aug. 31, 07. 2 figs. 2400 w. 20c. II. Points to be ascertained and precautions to be taken in the examination and valuation of placer ground before exploitation.

The Lordsburg Mine Region, New Mexico. Fayette A. Jones. Eng & Min Jl—Sept. 7, 07. 2 figs. 2200 w. 20c.

The Question of Riffles. Eng & Min Jl—Sept. 7, 07. 2 figs. 1200 w. 20c.

Gypsum.

Montana Gypsum Deposits. J. P. Rowe. Mines & Min—Sept., 07. 3 figs. 3500 w. 40c.

Metallic Sulphides.

Metallic Sulphides in the Tuffs of Santo Domingo. F. Lynwood Garrison. Min & Sc Pr—Sept. 7, 07. 6 figs. 5400 w. 20c.

Minerals and Water Solutions.

The Interaction between Minerals and Water Solutions. Eugene C. Sullivan. Min Jl—Sept. 20, 07. 4100 w. 40c. U. S. Geological Survey Bulletin No. 312. Describes the subject with special reference to geological phenomena.

Mining Methods.

Hydraulic Mining in Cariboo, B. C. Douglas Waterman. Min & Sc Pr—Sept. 7, 07. 4 figs. 1800 w. 20c.

Present Methods of Deep Alluvial Mining. H. L. Wilkinson. Min Wld—Sept. 7, 07. 2 figs. 1600 w. 20c.

Square-Set Mining and a Modification of It. Claude T. Rice. Min & Sc Press—Sept. 21, 07. 1 fig. 2500 w. 20c.

The Debris from Hydraulic Mining in California. Major William W. Harts, U. S. A. For & Irrig—Sept. 5, 07. 5 figs. 1500 w. 40c.

The Mechanical Engineering of the Mine. Chas. C. Christensen. Eng Mag—Oct., 07. 14 figs. 8400 w. 40c. A summary of methods and equipment employed in modern ore dressing and treatment.

New Caledonia.

New Caledonia and Its Minerals. G. M. Colvocoresses. Eng & Min Jl—Sept. 21, 07. 6 figs. 2500 w. 20c.

Nickel.

Nickel Mining in New Caledonia. G. M. Colvocoresses. E & M Jl—Sept. 28, 07. 5 figs. 4300 w. 20c.

The Sudbury Nickel-Copper Field, Ontario. I. Ralph Stokes. Min Wld—Sept. 28, 07. 5 figs. 4000 w. 20c.

Pyrite, Oxidation of.

The Oxidation of Pyrite. Alexander N. Winchell. Mines & Min—Sept., 07. 1 fig. 1800 w. 40c.

Quartz Mill.

The Humphreys' Quartz Mill. C. E. Humphreys. Min Rep—Sept. 26, 07. 1 fig. 1100 w. 20c. Describes a mill embodying the pounding principle of the stamp-mill and the grinding-amalgamating principles of the arrastre.

Reinforced Concrete in Mining.

Reinforced Concrete in Mining Operations. Joseph H. Hart. Min Wld—Sept. 28, 07. 1 fig. 2000 w. 20c.

Silver.

The Cobalt Silver Field, Ontario. Ralph Stokes. Min Wld—Aug. 31, 07. 6 figs. 4300 w. Sept. 7. 4 figs. 3300 w. Each 20c.

The Daly-Judge Mine and Mill. Paul A. Gow, Andrew M. Howat, George S. Kruger and F. H. Parsons. Concluded from August. Mines & Min—Sept., 07. 7 figs. 5500 w. 40c.

The Montreal River Silver Districts. Reginald Meeks. Eng & Min Jl—Sept. 21, 07. 8 figs. 4300 w. 20c. Describes a new district 60 miles from Cobalt, covering an area of about 80 square miles.

Zinc.

Zinc Ores and Manufactures Therefrom. W. G. Scott. Min Wld—Sept. 14, 07. 2500 w. 20c.

MUNICIPAL ENGINEERING

REFUSE DESTRUCTION.

Garbage Disposal and Street Cleaning. Alexander Potter. Mun Engg—Oct., 07. 2300 w. 40c. From an address before the League of Cities of the Third Class in Pennsylvania, McKeesport, Sept. 11-12.

Municipal Matters in Great Britain and America, and on the Continent. I. W. Calder. Surv—Sept. 13, 07. 2700 w. Sept. 20. 3800 w. Each 40c. Discusses refuse destructors used in Great Britain.

The Disposal of Municipal Waste. W. F. Morse. Mun Jl & Engr—Sept. 4, 07. 9 figs. 5700 w. 20c. Describes various systems and methods with special reference to American conditions; high temperature destructors; the cell and the continuous grate.

ROADS.

Macadam Road, Cost of.

Cost of a Macadam Road in Maryland. *Engg*-Contr—Sept. 25, 07. 1000 w. 20c.

SEWERAGE.

Plumbing.

Roughing-In Plumbing in Buildings. J. K. Allen. Dom Engg—Aug. 31, 07. 5 figs. 1700 w. Sept. 14. 2 figs. 2200 w. Sept. 28. 1 fig. 2200 w. Each 20c.

The Sanitary Sewerage of Buildings. Thomas S. Ainge. Dom Engg—Sept. 21, 07. 3 figs. 1300 w. 20c. VII. Traps.

The Drainage of a Detached House. F. J. Deacon. Surv—Sept. 13, 07. 8 figs. 3300 w. 40c.

Proper Sanitary Fixtures for Schools. Dr. Porter. Dom Engg—Sept. 7, 07. 4000 w. 20c. Paper read at the International Congress on School Hygiene, held in London, August, 1907.

Sewage Purification.

Comparative Résumé of the Sewage Purification Tests at Columbus, Ohio. George W. Fuller. Jl Assn of Engg Socs—Aug., 07. 10,000 w. 60c.

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Every Advertiser is entitled to entry in this Directory without additional charge. Others may have entry of Name and Address under suitable headings at $5.00 per line a year. Headings will be established to meet requirements.
When writing to any of these concerns please mention TECHNICAL LITERATURE.

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Architects' and Engineers' Supplies:
Buff & Buff Co., Boston, Mass.
C. M. Higgins & Co., 271 9th St., Brooklyn, N. Y.
E. G. Ruehle & Co., 119 Fulton St., New York.
Architectural Iron Works:
Harvey Thompson, 176 East 119th St., New York.
Boiler Makers' Tools:
Richard Dudgeon, 26 Columbia St., New York.
Books, Architectural:
Wm. T. Comstock, 23 Warren St., New York.
Books, Miscellaneous:
G. & C. Merriam Co., Springfield, Mass.
Technical Literature Co., 220 Broadway, New York.
Books, Technical:
M. C. Clark Pub. Co., 353 Dearborn St., Chicago.
Wm. T. Comstock, 23 Warren St., New York.
Engineering News Book Dept., 220 Broadway, New York.
McGraw Publishing Co., 114 Liberty St., New York.
Munn & Co., 361 Broadway, New York.
Railway Age, Chicago, Ill.
Chas. M. Sames, Jersey City, N. J.
Spon & Chamberlain, 123T Liberty St., New York.
Technical Literature Co., 220 Broadway, New York.
D. Van Nostrand Co., 23 Murray St., New York.
John Wiley & Sons, 43 East 19th St., New York.
Calculating Machines:
Clipper Mfg. Co., 403 West 124th St., New York.
Edge Computer Sales Agency, 220 Broadway, New York.
Oscar Muller & Co., 32 Broadway, New York.
Cement, Natural and Portland:
Hammerstein & Denivelle Co., 451 W. 54th St., New York.
Lawrence Cement Co., 1 Broadway, New York.
Western Cement Co., 277 West Main St., Louisville, Ky.
Chemists:
Dr. Peter T. Austen, 80 Pine St., New York.
Monadnock Laboratories, Chicago, Ill.
Cigars:
La Reclama Cuban Factory, 1030 Third Ave., New York.
Clocks:
Automatic Time Stamp Co., 164 Congress St., Boston, Mass.
Prentice Clock Imp. Co., 92 Chambers St., New York.
Concrete, Reinforced:
Concrete-Steel Eng. Co., Park Row Bldg., New York.
Concrete Specialist:
William Deane Ham, Jamaica, N. Y.
Consulting Engineers:
Concrete-Steel Eng. Co., Park Row Bldg., New York.
Drawing Materials:
C. M. Higgins & Co., 211 9th St., Brooklyn, N. Y.
E. G. Ruehle & Co., 119 Fulton St., N. Y.
Emery:
Tanite Co., Stroudsburg, Pa.
Employment Bureaus:
Hapgoods, 305 Broadway, New York.
Engineers' Supplies, Instruments, Etc.:
Buff & Buff Co., Boston, Mass.
E. G. Ruehle & Co., 119 Fulton St., New York.
Glass Workers' Tools:
Tanite Co., Stroudsburg, Pa.
Grinding Machines:
Tanite Co., Stroudsburg, Pa.
Hardwood Floor Construction:
J. O. Beers, 1 West 34th St., New York.
Hydraulic Cement:
Western Cement Co., 227 West Main St., Louisville, Ky.
Illuminating Engineers:
Bureau of Illuminating Engineers, 437 Fifth Ave., New York.
Insulated Wire:
India Rubber & G. P. Ins. Co., 253 Broadway, New York.
Jacks, Hydraulic:
Richard Dudgeon, 26 Columbia St., New York.
Lead Covered Cables:
India Rubber & G. P. Ins. Co., 253 Broadway, New York.
Metal Workers' Tools:
Tanite Co., Stroudsburg, Pa.
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Clipper Mfg. Co., 403 West 124th St., New York.
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C. L. Parker, 24 Dietz Bldg., Washington, D. C.
Joshua R. H. Potts, 80 Dearborn St., Chicago.
Periodicals, Technical:
American Builders' Review, San Francisco.
Architectural Record, New York.
Architects' & Builders' Magazine, New York.
Canadian Machinery & Mfg. News, Toronto.
Canadian Municipal Journal, Montreal, Que.
Cement Age, New York.
Compressed Air, New York.
Concrete, Detroit, Mich.
Electric Railway Review, Chicago.
Electrical World, New York.
Electrochemical & Metallurgical Journal, New York.
Electrical World, New York.
Engineering-Contracting, Chicago.
Engineering News, New York.
Engineering Record, New York.
Engineers' Club of Philadelphia, Philadelphia.
Forestry and Irrigation, Washington, D. C.
Iron Age, New York.
Mines and Minerals, Scranton, Pa.
Railway Age, Chicago.
Roadmaster and Foreman, Chicago.
Sibley Journal of Engineering, Ithaca, N. Y.
Street Railway Journal, New York.
Phonographs:
Duplex Phonograph Co., 303 Patterson St., Kalamazoo, Mich.
Piling, Steel:
Wemlinger Steel Piling Co., 11 Broadway, New York.
Polishing Machines:
Tanite Co., Stroudsburg, Pa.
Punches, Hydraulic:
Richard Dudgeon, 26 Columbia St., New York.
Schools and Colleges:
Armour Institute of Technology, Chicago.
Clarkson School of Technology, Potsdam, N. Y.
Lehigh University, South Bethlehem, Pa.
Ohio Northern University, Ada, Ohio.
Rose Polytechnic Institute, Terre Haute, Ind.
University of Michigan, Ann Harbor, Mich.
Signal Wire:
India Rubber & G. P. Ins. Co., 253 Broadway, New York.
Solid Emery Wheels:
Tanite Co., Stroudsburg, Pa.
Speed Indicators:
Tanite Co., Stroudsburg, Pa.
Steel Piling:
Wemlinger Steel Piling Co., 11 Broadway, New York.
Structural Steel Computer:
Edge Computer Sales Agency, 220 Broadway, New York.
Talking Machines:
Duplex Phonograph Co., 303 Patterson St., Kalamazoo, Mich.
Testing Laboratories:
Dr. Peter T. Austen, 80 Pine St., New York.
Monadnock Laboratories, Chicago, Ill.
Time Stamps:
Automatic Time Stamp Co., 164 Congress St., Boston, Mass.
Tube Expanders:
Richard Dudgeon, 26 Columbia St., New York.
Vanadium:
Vanadium Alloys Co., 25 Broad St., New York.
Wire, Insulated:
India Rubber & G. P. Ins. Co., 253 Broadway, New York.
Wood-Workers' Tools:
Tanite Co., Stroudsburg, Pa.

The Use and Abuse of Sewage Purification Plants. A. Elliott Kimberly. Surv—Aug. 30, 07. 5200 w. 40c. Paper read before the Ohio Engineering Society.

WATER SUPPLY.

Artesian Wells.

Water Supplies by Means of Artesian Bored Tube Wells. Herbert F. Broadhurst. Water—Sept. 16, 07. 2 figs. 3200 w. 40c.

Manila's Water and Sewerage System.

The New Water and Sewerage System of Manila, P. I. Eng Rec—Sept. 14, 07. 6 figs. 2800 w. 20c.

Purification.

Direct and Indirect Methods of Electrical Purification of Water. Henry Leffmann. Jl of Franklin Inst—Sept., 07. 5 figs. 2500 w. 60c.

Examination of Water Purification Plant at Owensboro, Ky. Philip Burgess. Eng Rec—Sept. 28, 07. 2 figs. 1900 w. 20c.

The Circular Tanks at the Lancaster Filtration Plant. Eng Rec—Sept. 14, 07. 5 figs. 1400 w. 20c.

The Development of Mechanical Filtration. Robert E. Milligan. Water—Sept. 16, 07. 3 figs. 5800 w. 40c. From a paper read before the Western Society of Engineers.

The Water Purification Plant of Harrisburg, Pa. Mun Engg—Oct., 07. 9 figs. 4000 w. 40c. Describes the operation of the filters and apparatus used.

Softening Plant.

McKeesport's Water Softening Plant. Mun Jl & Engr—Sept. 4, 07. 5 figs. 4500 w. 20c. Describes the 10,000,000-gal. municipal plant now under construction, the caustic lime and soda ash process used, provision made for carbonating and other details of process and construction.

Stream Pollution.

Court Decision against the Pollution of a Brook in Dracut, Mass., by the American Woolen Co. Eng News—Sept. 5, 07. 4300 w. 20c. Gives text of a sweeping court decision regarding the discharge of wastes from a woolen mill into a small stream.

Some Relations of Stream Pollution and Water Purification. Charles C. Brown. Mun Engg—Oct., 07. 1900 w. 40c.

Valuation of Plants.

Valuation of Water-Works Plants. Mun Jl & Engr—Sept. 11, 07. 2400 w. 20c. From a paper read before the Wisconsin League of Municipalities, by Charles R. Burdick, showing methods used by appraisement boards for determining physical value, going value and franchise value and the probable life of water-works structures.

Water-Testing Laboratory.

Laboratory of the New York Board of Water Supply. James L. Davis. Mun Jl & Engr—Sept. 18, 07. 6 figs. 2800 w. 20c. Describes the physical testing of cement and concrete by tension and compression; permeability; tests of aggregate; chemical laboratory; soil analyses.

MISCELLANEOUS.

London Sanitary Law, Administration of.

Administration of Sanitary Law in London. John Lawrence. Surv—Aug. 30, 07. 3000 w. 40c. Paper read at the summer meeting of the Institute of Sanitary Engineers, at Margate.

Municipal Use of Patented Articles.

Municipal Use of Patented Articles. James M. Head. Mun Jl & Engr—Sept. 4, 07. 2800 w. 20c. A consideration of present status of supreme court decisions and legislative enactments affecting patented articles for public improvements.

RAILROAD ENGINEERING

CONSTRUCTION.

Australia.

The Railways of Australia. P. Privat-Deschanel. Genie Civil—Sept. 7, 07. 7 figs. 5000 w. Sept. 14. 1 fig. 2200 w. Each 60c.

Cost Keeping on Railroad Construction.

Cost Keeping on Railroad Construction. Engg-Contr—Sept. [illegible], 07. [illegible] w. 20c.

Florida East Coast Extension.

Florida East Coast Railway Extension. Howard Egleston. Engg-Contr—Sept. [illegible], 07. 2 figs. 1800 w. 20c. I. General situation.

Mexico.

The Railroads of Mexico. Erdis G. Robinson. R R Gaz—Sept. 13, 07. 5 figs. 2500 w. Location and Construction. Sept. 20. [illegible] w. Operation. Each 20c.

Philippines.

Philippine Railroad Building with Filipino Laborers. R R Gaz—Sept. 20, 07. 2 figs. [illegible] w. 20c.

Southern Ry.

The Southern's New Line from Jasper, [illegible]. R R Gaz—Sept. 6, 07. [illegible] figs. [illegible] w. 20c.

Western Pacific Ry.

[illegible] Features of the Western Pacific Railway. George P. Low. Eng Rec—Sept. [illegible], 07. [illegible] figs. 3400 w. 20c.

Notes From the Diary of the Advertising Man

Money invested in advertising, like other investments, can be foolishly dissipated or wisely expended. The persistent, patient advertiser who has something to say and who says it strikingly will attract attention and bring results. The plunger who wastes space in extravagant and hackneyed assertions may also attract notice for a time, but will not invite the confidence or the trade of the reader. —"New York Times."

Persistence is the foundation stone—the absolute essential—of all successful advertising. The firm that advertises this month and stays out next month runs a poor chance of making a distinctive impression on TECHNICAL LITERATURE readers. It doesn't matter when you begin to advertise. It does matter a great deal to you how long you continue.

The firms that advertise are the live ones. Some of them are long-established; some are new and struggling for reputation and trade. Some are large; many are small. But all of them are alive; progressive; looking forward, not backward; growing, not declining. Advertising—sensible, reasonable, persistent advertising—is a sure sign of business life.—Nugent.

If we could think quite analytically and see the advertisement as it is, and as a thing independent of its environment, it might be profitable to place our advertisements on garbage boxes and in cheap and disreputable publications. As we are constructed, however, such a course would be suicidal, even for a house dealing in disreputable and cheap articles. The medium gives a tone of its own to all the advertisements contained in it. I feel inclined to respect any firm that advertises in a high-class magazine, unless there is some particular reason to the contrary, and willing to trust to its honesty.

"Nothing except the mint," said Mr. Gladstone, "can make money without advertising."

"Spasmodic, or sporadic, advertising is good while it lasts. But it seems to imply when it stops that the article offered has stopped, too."—"Printers' Ink."

MANAGEMENT AND OPERATION.

Co-operation of Mechanical and Operating Departments.

Co-operation between the Operating and Mechanical Departments. L. A. W. Wheatley. Am Engr & R R Jl—Sept., 07. 1200 w. 40c. Gives suggestions for decreasing the cost of locomotive repairs.

Handling Trainmen.

Handling Trainmen at Knoxville. St Ry Jl—Sept. 14, 07. 4 figs. 1000 w. 20c. Contains reproductions of forms such as train orders, inspectors' reports, discipline reports, etc.

POWER AND EQUIPMENT.

Gasoline Motor Cars.

Gasoline Locomotives and Motor Cars. Eng News—Sept. 5, 07. 2 figs. 2200 w. 20c. Describes light cars for branch line service and for contractor's use.

Locomotives.

A Note on Compound Locomotives. M. Maurice Demoulin. Engr—Aug. 30, 07. 2 figs. 3900 w. 40c. Conclusion.

British 4-Cylinder Locomotives. Charles S. Lake. Ry Age—Sept. 27, 07. 6 figs. 2500 w. 20c.

Eliminating Smoke with Locomotives Burning Soft Coal. Eng News—Sept. 19, 07. 2400 w. 20c. Abstract of a report presented at the annual meeting of the Traveling Engineers' Association, Chicago, September.

Express Passenger Engine, Midland Railway. The Valve Gear. Engr (Lond.)—Sept. 20, 07. 10 figs. 1800 w. 40c. Describes a new valve-gear which gives a valve movement and steam distribution identical with Stephenson's except as regards the lead, but without eccentrics.

Goods Locomotive for the Lancashire and Yorkshire Railway. Engg—Aug 23, 07. 8 figs. 1200 w. 40c.

Hot Water Boiler Washing. Ry & Engg Rev—Sept. 7, 07. 2600 w. 20c. Abstract of Committee Report to Traveling Engineers Association.

Locomotive Characteristic Curves. J. G. Crawford. Ry M M—Sept. [illegible] 5 figs. [illegible] w. 20c.

Locomotive Piston Valves. H. R. Stafford. [illegible] Sept. [illegible] figs. [illegible] w. [illegible] Continued.

[illegible] Ry M M. [illegible]

[illegible]

[illegible] Locomotive [illegible] Sept. 28, 07. 16 [illegible]

Superheated Steam and the Best Method of Getting Good Results when Engines are in Service on Trains. Ry & Engg Rev—Sept. 9, 07. 1000 w. 20c. From committee report to Traveling Engineers' Association.

Superheated Steam Locomotives in Germany. Mech Engr—Sept. 14, 07. 6 figs. 2600 w. Sept. 21. 8 figs. 2600 w. Each 40c.

The Locomotives of the Atchison, Topeka & Santa Fe Railway. Engr (Lond.)—Sept. 13, 07. 14 figs. 2200 w. 40c. Gives details of the various types used by this road.

The Waste of Energy in Railroad Operation. D. C. Buell. Ry & Engg Rev—Sept. 7, 07. 2600 w. 20c. Abstract of paper presented before the Traveling Engineers' Association.

Rails.

Wheel-Loads and Rail-Weights. H. S. Hodgins. Cass Mag—Oct., 07. 11 figs. 2300 w. 40c. Discusses the effect of increased wheel-loads and shows how the weight and section of the rail has been increased to meet the demands upon it.

Shops.

Car Repair Shops at East Decatur, Wabash Railroad. Ry M M—Sept., 07. 28 figs. 3200 w. 20c.

New Frisco Shops. Ry & Engg Rev—Sept. 7, 07. 19 figs. 4300 w. 20c. Describes new repair shops under construction at Springfield, Mo.

The New Springfield (Mo.) Shops of the Frisco System. Ry Age—Sept. 6, 07. 14 figs. 4400 w. 20c.

The Frisco Shop Proposition. Ry & Eng Rev—Sept. 14, 07. 14 figs. 5300 w. 20c.

Signaling.

Railway Signaling. J. B. Struble. Elec Jl—Sept., 07. 10 figs. 3500 w. 20c.

Steel Cars.

All-Steel Passenger Cars. Pennsylvania Railroad. II. Ry M M—Sept., 07. 8 figs. 1400 w. 20c.

Terminals.

American Railway Stations and Platforms. Dr Blum and E. Giese. Z V D I—Sept. [illegible] 07. [illegible] figs. 5000 w. 60c.

Proposed Improvement of Passenger and [illegible] Terminals at Buffalo. Ry & Eng Rev—Aug. [illegible] 07. 4 figs. 3300 w. 20c.

Ties.

[illegible] Concrete-Steel Ties. Ry Age—Sept. [illegible] figs. 1200 w. 20c. Describes a [illegible] type of tie now being used [illegible] and Pere Marquette [illegible]

Steel Ties in Germany. N. C. A. Hoarmann. [illegible] Sept. 27, 07. 4 figs. 1800 w. [illegible] description of ties used abroad, with conditions for obtaining best results.

Contents of September Issue

Turntables.

Modern Turntables.—I. Ry Age—Sept. 13, 07. 10 figs. 2500 w. 20c.

STREET AND ELECTRIC RAILWAYS.

Brakes, Tests of.

The Testing of Tramway Brakes. W. Park. Tram & Ry Wld—Sept. 5, 07. 1100 w. 40c.

Car Tests.

Service Tests on Columbus City Cars Operated Singly and in Two-Car Trains with Multiple Unit Control. St Ry Jl—Aug. 31, 07. 3500 w. 20c.

Current Collector, Overhead.

A New Design of Overhead Current Collector. El Ry Rev—Sept. 7, 07. 2 figs. 500 w. 20c. Describes a new current-collecting device which gives a larger contact surface than the ordinary trolley wheel and overcomes one of the defects of the ordinary sliding-bar system.

Electrically Equipped Roads.

Electric Tramways in St. Petersburg. El Engg—Sept. 12, 07. 3 figs. 2,000 w. 40c.

Great Western Railway: Electric Power and Lighting and the Electrification of the Hammersmith and City Railway. El Engr—Aug. 23, 07. 5 figs. 2500 w. Aug. 30. 3 figs. 2600 w. Each 40c.

Manchester (England) Corporation Tramways. Tram & Ry Wld—Sept. 5, 07. 27 figs. 8600 w. 40c. An exhaustive account of the experiment and methods of operation of this extensive tramway system.

The Installation of Electric Traction on the New York Terminal Section of the New Haven Railroad. Eng News—Sept. 5, 07. 12 figs. 1700 w. 20c. Gives a description of the overhead construction, the locomotives and power station.

The Visalia Electric Railway. Arthur H. Halloran. Jl of El P & Gas—Aug. 31, 07. 9 figs. 3100 w. 20c. Describes the single-phase, fifteen-cycle, 3,300-volt railway now nearing completion between Visalia and Lemon Grove, Cal.

Electric Traction.

[illegible] Cars on Standard-Gauge Railways. Dr. [illegible] Gradenwitz. [illegible] Sept. [illegible] 2 figs. [illegible] 20c. Describes operations on suburban lines at [illegible] Germany.

[illegible] Railways. [illegible]

[illegible]

[illegible] Trac- [illegible] 20, 07. [illegible]

Freight Traffic.

Expansion of Electric Freight Traffic. A. S. Atkinson. Ry & Mar Wld—Sept., 07. 1300 w. 40c.

Performance Records.

Records of Parts. El Tr Jl—Sept. 5, 07. 14 figs. 700 w. 20c. Describes a system of keeping mileage performance records on individual parts.

Power Plants.

Long Island City Power Station of the Pennsylvania Railroad Company. No. 1. Engg—Aug. 30, 07. 13 figs. 4800 w. 40c.

Power Plant of the Antwerp Railway. F. C. Perkins. W. Elecn—Sept. 21, 07. 6 figs. 1800 w. 20c.

The Hochelaga Power House of the Montreal Street Railway. Can El News—Sept., 07. 4 figs. 2500 w. 20c.

Rail Bonding.

Contact Resistance in Connection with Rail Bonding. St Ry Jl—Sept. 14, 07. 7 figs. 2200 w. 20c. Discusses contact resistance with special reference to compression bonds.

Railway Motors.

1,200-Volt and Commutating Pole Direct-Current Railway Motors. E. H. Anderson. El Ry Rev—Sept. 28, 07. 1 fig. 2300 w. 20c. Read before the Central Electric Railway Association, Columbus, O., Sept. 26.

Regeneration of Power with Single-Phase Electric Railway Motors. William Cooper. Proc Am Inst El Engrs—Aug., 07. 9 figs. 3400 w. 80c. A paper read before the American Institute of Electrical Engineers, Niagara Falls, June 28.

Reconstruction of Elevated Road.

Reconstruction of the South Side Elevated Railroad, Chicago. El Ry Rev—Aug. 31, 07. 11 figs. 2700 w. 20c.

Signaling.

Track Circuit Signaling on Electrified Roads. L. Frederic Howard. Proc Am Inst El Engrs—Aug., 07. 11 figs. 4500 w. 80c. A paper read before the American Institute of Electrical Engineers, Niagara Falls, June 28.

Track.

[illegible] Track Construction at Milwaukee. [illegible] 2 figs. 700 w. 20c.

[illegible] Grade Crossings in New [illegible] Zone. Eng Rec—[illegible] figs. [illegible] w. 20c.

[illegible] E. Goulding. Tram [illegible] 2 figs. 1100 w. [illegible]

[illegible] of the Pacific Electric [illegible] Interurban Railways. [illegible] figs. 1600 w. 20c.

// TECHNICAL LITERATURE

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THE MANUFACTURE OF FILES

CONDENSED FROM "MACHINERY"

Blanking and Forging.—The raw material received comes in various forms, generally of the exact shape of the "amid-ships" section of the file. In a few cases sheet stock is used for thin flat files of various forms and uniform thickness. These are punched in blanking dies under a punch press. For half-round, round, square, barrette and other styles, stock of appropriate shape is cut in the shears to the proper length. From here it is taken to the forging department. A furnace stands at the side of each smith, and a very small and inconspicuous affair it is. A fire-brick lining in an iron casing with four legs to stand on, with piping and burners for gas and air, is all there appears to be to the apparatus. The furnaces are quite small, being only just wide enough for the length of the files being heated. The uniformity of the temperature throughout the whole area of the furnace is remarkable, there being no difference visible to the eye in color anywhere within the heated area. The first operation is the forming of the tang. Then the blanks are reheated, and worked to the proper shape under dies. The face of each die is made in three sections. That on one side of the die is used for breaking down the stock, that on the other side for bringing the edge of the stock to approximately the right dimension, while the central section is used in forming the sides or faces of the blank. The workmen handle these with great rapidity and dexterity, changing the work quickly from one side to the other, and back again to the middle, turning and re-turning the blank until it is formed to the shape determined by the dies. It is impossible to form some shapes correctly under the power hammer. The barrette, and the point of the half-round, for instance, have to be finished by drop forging. The former shape of file is struck up from a round blank. The amount of scale found around the hammers and drop presses is very small—an indication of the non-oxidizing quality of the flame in the gas furnace. Each workman has a private supply of cool air from the pressure service which he can direct on himself in whatever way best suits his convenience and comfort.

Annealing.—This is the next operation after the forging. One might expect from the importance of this part of the work to find elaborate precautions taken. One would suppose that the blanks would be packed with charcoal in cases having covers luted with fireclay; such precautions are generally considered necessary to get even heat and freedom from oxidation. Nothing of this kind, however, is seen. The blanks are packed in the furnaces, unprotected, exposed to the direct action of the flame. The precaution of packing them with the tangs outward and the points inward is taken, but otherwise the metal is not shielded in any way. The flame is lighted and kept going at a temperature of 1,500° F., for about four hours, ordinarily; then (the doors being carefully closed) the work is allowed to remain over two nights and one day, until it is perfectly cool. There is a very slight, thin scale resulting from this heat treatment, but no pitting or corrosion. What little scale there is comes from air which leaks in during the cooling process, the flame itself being absolutely non-oxidizing. It would be difficult to find a better commercial test of the excellence of the fuel gas process used than this.

The uniformity of annealing obtained is the result of the fulfillment of several simple conditions. There must be a constant quality pressure and amount of gas, and a constant pressure and volume of the air mixed with it. With these mixtures determined, the nature of the flame and the temperature will be constant. Too much cannot be said about the composition of the flame. The vaporized naphtha used is free from injurious elements, such as sulphur, and is provided with a slight under supply of oxygen, so that there is no danger of that element combining with the metal. The furnace must be so built that the heat is evenly distributed throughout the whole of the interior. The file on the bottom of the pile must be heated under the same conditions as the one at the top. The ends and sides of the furnace must each be subject to exactly the same degree of heat. With these points carefully looked out for, and with the matter of time of exposure to the heat attended to, it only remains to provide the proper steel to be able to get the same results day in and day out, in the annealing of file blanks.

Grinding and Stripping.—In order to form sharp teeth of uniform height, it is necessary to provide a smooth, even surface to start with. To produce this surface the blanks are first ground and then draw filed or "stripped." The files with flat cutting surfaces have them ground on automatic machines. A near view of one of these machines is shown in Fig. 1. At B is a grindstone of large diameter, revolved at suitable speed and traversed slowly back and forth by a cam, to equalize the work across its face. The files, shown at A, are ranged in a row, with suitable backing and supports, on the flat plate or holder, C. This frame or holder is propped in a vertical position in slide D, and pressed up against the face of the revolving grindstone B by the rollers E and the adjusting screws operating them. The mechanism which reciprocates slide D up and down, so that the blanks are ground from one end to the other, is then started. In the machine shown this motion is operated by an adjustable crank at the top of the machine, connected to crosshead C. The matter of grinding a frame full of blanks is one of a few strokes

Courtesy of "Machinery."

FIG. 1. MACHINE FOR GRINDING FLAT FILES.

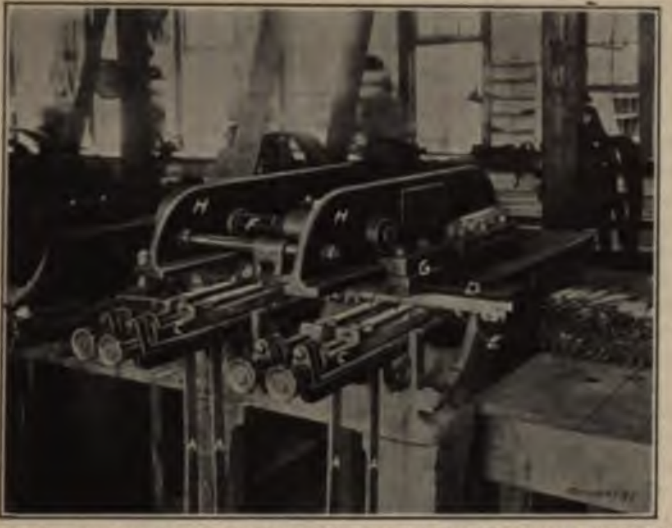

FIG. 2. STRIPPING MACHINE FOR DRAW FILING THE BLANKS.

and a few seconds only. The wheels used are five or six feet in diameter, and means are provided in the machine for keeping them constantly trued.

This machine grinding is done on flat surfaces only. On round surfaces the grinding is done by hand.

The surface produced by this grinding is not quite good enough for the purpose desired, so the finishing touches are given by draw filing or "stripping." Both flat and round surfaces are finished in this way, and all burrs are removed from edges and corners. The men work at benches, with the blanks supported by their ends in wooden blocks. For stripping flat surfaces, a new machine has recently been introduced. One of these is shown in Fig. 2. The blanks, B, are held in suitable holders. These holders are pressed upward by levers and weights against the cutting files E, in slide D. This slide is moved in and out for the stroke, being carried by saddle G, which slides along ways on the under side of overhanging arms H H. It is also traversed back and forth to distribute the action over the full length of the cutting files by a drunken screw at F. The work is relieved from contact with the files on the back stroke. It might be expected that it would be a matter of some difficulty to avoid "pinning" in a case of this sort. This is not often met with, however. In the first place the files are made specially for the purpose, with plenty of clearance. Besides this, the pressure on the work is unvariable, being determined by the weights and levers mentioned. A workman, even though expert, might momentarily use more pressure than he ought to on his file so as to cause it to tear the steel and get the broken particles wedged or "pinned" in the teeth. With a machine, having once found the conditions necessary to avoid this trouble, these conditions may be preserved indefinitely, and the trouble practically avoided. When it does occur, perhaps once a day, the blank thus injured has to be reground and refiled.

Flat files are ground and stripped on all of their cutting surfaces before going to the cutting department. On files having sharp edges, however, such as half-round, barrette, and other shapes, this course is not followed. On a half-round file, for instance, the flat surface is stripped; then the first cut is taken over it, and it is returned to the stripping room to have the round surface finished, which then, in turn, is treated with the first cutting; after this the second cut is given to the flat side, and then to the round side. This working first on one side and then on the other, on a blank having sharp edges, is necessary to keep the teeth perfect in shape clear out to the edge. If one side were finished completely before the other was touched, the edges would be turned over, away from the surface last finished, making a sharp burr on the side which was cut first.

After the blanks have been stripped, they are taken to the blank storage, awaiting their turn at the cutting machines.

File-Cutting Machines.—A file-cutting machine provides, essentially, means for striking a series of rapid blows with a suitably formed

chisel to any desired depth, and means for feeding a file blank past the chisel at such a rate of speed as to give the desired spacing of the tooth.

The machine shown is driven by the belt and pully at A. A cam is keyed to the driving shaft which, through a lever, raises the ram in head C against the resistance of an India rubber spring D, and allows it to fall again freely. The chisel E, held in the end of the ram, is thus able to deal a series of very rapid blows on the blank beneath it, the shaft revolving at a high rate of speed, and the cam having several lobes or teeth. The work F is laid on a holder G, resting on the inclined bed of the machine. It is fed along under the chisel, being drawn by a plate B, which is clamped between friction rolls at H. These rolls are driven at a uniform rate of speed, through gears and belting, from the main shaft of the machine. No provision is made for varying the spacing in a file, the makers believing that there is no virtue in the "increment" cut, but that there is a decided advantage in having the file uniform from end to end.

The presser foot J, under the influence of a weight, follows the work just in front of the chisel and holds it firmly down to the holder G. The latter has a cylindrical bearing on a seat in the bed, so that on flat files the blank is free to adjust itself under the pressure foot until the surface is parallel to the cutting edge of the chisel. In the case of half-round files, the holder is rocked by handle K to bring under the influence of the chisel any part of the surface desired. The distance between the work and the chisel may be altered by crank M, so the depth of cut may be varied at will. This is important, and much of the skill of the cutter lies in his adjustment for depth of cut. It is a vital requirement that the teeth be uniform from end to end. On a tapering file, such for instance as the flat side of a half-round, a blow on the point of the file of the same force as that delivered in the middle section, where the blank is widest, would make so deep a cut as to almost sever the blank. The workman, then, in running from the point to the heel, starts in lightly, increasing the force of the blow by adjusting the crank M as the width of the blank changes. The setting of the bed on an angle as shown, and the continuous feeding of the blank while the blows are being struck, has the effect of opening up the teeth as the chisel leaves each cut.

Etching of Teeth in Files.—Most mechanics are familiar with the idea of file-cutting with a chisel by hand or machine, but how many of them are aware of the fact that great quantities of the files they use are not made with the chisel at all, but by a grooving process somewhat akin to knurling, and known as "etching?" The workmen shown in Fig. 4 are employed in this work. The file being treated is laid in the holder, as shown, where it is steadied and guided by the workman's left hand. With his right hand, by the handle which it grasps, he operates the etching tool attached to the swinging framework. This tool is a triangular bar with file teeth cut in each of its three edges. Any one of these edges may be presented to the work. The cutting of these teeth is an art in itself. They have to be made with uniform depth and regu-

FIG. 3. FILE-CUTTING MACHINE.

FIG. 4. PROCESS OF "ETCHING" TEETH ON FILES.

ty, since it is necessary for the teeth to ck" in the grooves previously cut in the k. The etching tool is simply swept back forth across the work at the proper angle with the proper degree of pressure, as de- nined by the foot of the operator bearing n on the stirrup shown hanging from the dle. The teeth on the edge of the tool cut trace out the grooves which are to form teeth of the file. Simple as the process nds, it requires a high degree of skill. No e training is necessary to give the steadi- s of movement, evenness of pressure, and ness of positioning needed. In the case round and half-round surfaces, the tool is pt across the blank in a series of strokes n one end to the other in one portion of the face. The blank is then rotated a little and on until the whole surface is covered. So l must the etching tool be made, however, so careful is the work, that the teeth are tinuous throughout the whole surface.

he shape of the file is the consideration ch determines whether a blank shall be ed or cut with the chisel. A flat surface not be etched, nor is there any need for it. round surfaces, however, particularly re it is necessary to preserve accurately outline of the blank, etching is preferable utting. In a round file, the action of the el throws up the stock in such a way that shape is polygonal, rather than round, n the file is completed. In etching, on the trary, the process is that of cutting out the al, leaving the original contour undis- bed. The workman cuts in with his etching tool only enough to bring the teeth to a sharp edge, without bringing this edge below the original surface. For this reason, in any curved shape where an accurate outline is desired, etching is the process used. Teeth coarser than No. 1 cannot readily be formed in this way, owing to the difficulty of applying enough pressure, and at the same time guiding the tool with precision.

Hardening.—After the forming of the tooth, either by cutting or etching, the maker's name and the number are stamped on the file, and the extreme end, where the teeth are not perfectly formed, is sheared off. Then it goes to the hardening department. The equipment of the room consists of two hardening furnaces, with lead baths, suitable brine tanks and brine cooling apparatus, and appliances for cleaning the files by a steam blast carrying a powdered earthen material.

In hardening, the following procedure is adopted: A boy stands at the left of the furnace man, having at his left a pile of the files to be treated, and on the table back of him a supply of iron handles with sockets having holes pierced in them to match the tapered shanks of the files. At regular intervals, at such a rate as to always keep a certain number of files in the furnace, he inserts the shank of a file in the socket handle, which he lays on top of the furnace with the file hanging down into the pot of melted lead. The surface of the lead is covered with coke dust, to prevent oxidation, and the temperature is kept constant at about 1,600° by a Bristol pyrometer.

As each piece of work becomes thoroughly heated, the operator removes it, plunges it into the brine tank and then into lime water, where it is cleaned, and then holds it for a moment under a steam jet. This latter heats it so that it dries immediately, thus obviating the danger of rusting. In small files especially, the transfer from the furnace to the brine tank has to be made very quickly, in order to prevent cooling before the water is reached. For this reason two tanks are provided. The small one, close to the furnace, is for small files, which cool too rapidly to permit a long journey through the cool air. The large one, a little further back, is used for larger work. The body of water in the large tank does not heat up so rapidly, and there is less danger of cooling with these files in carrying them the greater distance required.

After the hardening there is a slight oxidation of the surface of the file, little more, however, than a stain; it could scarcely be called scale. To remove this the work is taken to the cleaning apparatus, which consists of sheet metal cases containing a quantity of water mixed with a fine clay. This clay is almost impalpable, with no perceptible grit that can be felt between the thumb and finger. A steam ejector draws the mingled water and clay from the bottom of the casing and directs it in a stream upward against the files, of which several at a time are grasped by the operator in a pair of long-jawed tongs. A few seconds' exposure to the blast, first on one side and then on the other, removes the stain from the cutting edges and leaves them bright and sharp. From here the files go to the packing department where they are inspected for hardness and accuracy of cutting, oiled, and wrapped in suitably labeled boxes ready for marketing.

Special Forms of Files.—What we have said of the methods of manufacture followed relates to files with more or less regular outlines, which readily admit of being formed and cut by machinery. Great numbers of special shapes have to be made, however, in which the use of machinery is impossible. In the case of the various forms of rifflers for instance used by toolmakers and diemakers in working out otherwise inaccessible corners, the whole work of forging, stripping, cutting, etc., has to be done by hand, the surface being too irregular to admit of any other procedure. Other special forms of files are made here for various purposes. One interesting product is a form used for sharpening pins. It will be news to many mechanics, doubtless, to know that the points of pins are filed. The filing is done by square blocks of steel with single cut teeth formed in them, fastened to the sides of rapidly revolving disks. Large quantities of these are made here.

The practice herein set forth is that of The American Swiss File and Tool Co., of Elizabethport, N. J.

INTERNAL-COMBUSTION ENGINES USING ALCOHOL FUEL

In Europe during the last ten years the high price of the petroleum oils used as fuel in internal-combustion engines has led to extended efforts to find other suitable and economical fuels. Among these alcohol has received much attention and there have been manufactured and used in Germany a considerable number of engines especially designed for this use.

The question of a possible substitute for the petroleum fuels will become of increasing importance as time goes on. The [illegible] to be obtained in the United States [illegible] ultimately diminish and the history of the past indicates that a constant increase in price of kerosene and gasoline may reasonably be expected. On the other hand, it is not unreasonable to hope that with improvements in agriculture and in processes of manufacture the cost of alcohol may fall, so that as regards cost alcohol may occupy a position of constantly increasing advantage in comparison with the petroleum oils.

Something like a year ago, Charles E. Lucke, Ph.D., assistant professor of mechanical engineering at Columbia University, was called upon to undertake an elaborate series of tests

on internal-combustion engines using alcohol fuel for the U. S. Department of Agriculture. The objects of this investigation were:

First, to determine whether the gasoline and kerosene engines at present on the American market can run on alcohol as fuel. This involved as related matters the determination of the manipulation to be followed in making the engines run on alcohol, the measurement of the relative maximum powers of the engines when using alcohol and the fuels for which they were originally made, and, lastly, the relative consumptions of the different fuels. Second, to determine, so far as the limited time and means available permitted, the improvements which might be desirable in the design of engines manufactured especially for alcohol.

Most of the engines used were loaned by their makers for the purpose of these tests. Each of the eight engines was run on alcohol as well as on the gasoline or kerosene for which it was designed. The engines used were:

No. 1. 15-HP. 2-cyl. vertical 4-cycle engine.
No. 2. 6-HP. horizontal 4-cycle engine.
No. 3. 6-HP. horizontal 4-cycle engine.
No. 4. 6 HP. vertical 4-cycle engine.
No. 5. 6-HP. horizontal 2-cycle engine.
No. 6. 40-HP. 4-cyl. automobile engine.
No. 7. 40-HP. 4-cyl. automobile engine.
No. 8. 2-HP. vertical 2-cycle marine engine.

All of these engines were gasoline engines, except No. 5, which was constructed to operate with kerosene. Nos. 6, 7 and 8 were, of course, high-speed engines.

A report on these tests has been prepared by Dr. Lucke and Mr. S. M. Woodward, of the Office of Experiment Stations, Washington, from which we reprint the following general conclusions.

1. Any gasoline engine of the ordinary types can be run on alcohol fuel without any material change in the construction of the engine. The only difficulties likely to be encountered are in starting and in supplying a sufficient quantity of fuel, a quantity which must be considerably greater than the quantity of gasoline required.

2. When an engine is run on alcohol, its operation is more noiseless than when run on gasoline, its maximum power is usually materially higher than it is on gasoline, and there is no danger of any injurious hammering with alcohol such as may occur with gasoline.

3. For automobile air-cooled engines alcohol seems to be especially adapted as a fuel, since the temperature of the engine cylinder may rise much higher before auto-ignition takes place than is possible with gasoline fuel; and if auto-ignition of the alcohol fuel does occur no injurious hammering can result.

4. The consumption of fuel in pounds per brake horsepower, whether the fuel is gasoline or alcohol, depends chiefly upon the horsepower at which the engine is being run and upon the setting of the fuel supply valve. It is easily possible for the fuel consumption per horsepower hour to be increased to double the best value, either by running the engine on a load below its full power or by a poor setting of the fuel supply valve.

5. The investigations also showed that the fuel consumption was affected by the time of ignition, by the speed, and by the initial compression of the fuel charge. No tests were made to determine the maximum possible change in fuel consumption that could be produced by changing the time of ignition, but when near the best fuel consumption it was shown to be important to have an early ignition. So far as tested, the alcohol fuel consumption was better at low than at high speeds. So far as investigated, increasing the initial compression from 70 to 125 lbs. produced only a very slight improvement in the consumption of alcohol.

6. It is probable that for any given engine the fuel consumption is also affected by the quantity and temperature of cooling water used, and the nature of the cooling system, by the type of ignition apparatus, by the quantity and quality of lubricating oil, by the temperature and humidity of the atmosphere, and by the initial temperature of the fuel.

7. It seems probable that all well constructed engines of the same size will have approximately the same fuel consumption when working under the most advantageous conditions.

8. With any good small stationary engine as small a fuel consumption as 0.70 lb. of gasoline, or 1.16 lbs. of alcohol, per brake horsepower hour may reasonably be expected under favorable conditions. These values correspond to 0.118 and 0.170 gal., respectively, or 0.95 pint of gasoline and 1.36 pints of alcohol. Based on the high calorific values of 21,120 B.T.U. per pound of gasoline and 11,880 per pound of alcohol, these consumptions represent thermal efficiencies of 17.2% for gasoline

and 18.5% for alcohol. But calculated on the basis of the low calorific values of 19,660 B.T.U. per pound for gasoline and 10,620 for alcohol, the thermal efficiencies become 18.5 for the former fuel and 20.7 for alcohol. The ratio of the high calorific values used above is, alcohol to gasoline, 1.66 by weight, or 1.44 by volume.

PROBLEMS OF APPLIED CHEMISTRY*

By PROFESSOR GEORGE LUNGE

We are, in these days, so much accustomed to deal with electricity in its innumerable applications, that we are apt to forget how recent is the introduction of that force of nature into practical chemistry. One of the finest heads among English alkali makers, whose grasp of the principles of science far surpassed that of most ordinary technical chemists, Dr. Ferdinand Hurter, pronounced himself, as late as 1888, decidedly against the commercial possibility of introducing electricity, as an agent for manufacturing the cheaper class of chemicals. But within a very few years of that date the contrary had become an established and well-known fact, even in his own domain of alkali. True, in hardly any field have there been more failures to translate the results of science into economical manufacturing processes than in that of electricity; and even now it is only quite exceptionally that, wherever the electric current has to be produced by means of steam, electrochemical methods can compete with the older ones for the manufacture of what is called "heavy chemicals." This is easily understood when we remember that about 90% of the heat value of coal, or its equivalent of energy, is lost in the circuitous routes of steam boiler, steam engine, and dynamo. But there are several ways in which the problem of obtaining cheaper electricity is being grappled with, and if most of these have to be dismissed for the present as belonging to the "music of the future," we have at least one which is a hard fact, and that is the generation of electricity by water-power. [illegible] it is a [illegible] European [illegible] the greatest producers of coal, Great Britain and Germany, should be less favored by nature in respect of water-power than other countries which possess little or no stores of mineral fuel, as Sweden, Norway, Switzerland, France, Italy, and Spain. A very different condition of affairs obtains in the United States, where we find the greatest coal-fields combined with the greatest amount of water-power existing in any civilized country. It is impossible to shut one's eyes to the fact that the day will inevitably come when the coal-fields will be so far exhausted that all those industries which consume large amounts of mechanical energy will be forced to emigrate to countries where water-power is abundant.

No other substitute has, as yet, been found for generating force, and, indirectly, electricity. True, the energy given out by the descent of water in rivers is but a small fraction of that which is radiated upon the earth from the sun, or of that which is developed by the play of the tides and the force of the wind, but no way has yet been found of utilizing these other sources of energy, except to the slenderest extent. The harnessing of these natural agents belongs, so far as we can see, to the class of problems which will hardly be solved by our own generation, whatever developments the remoter future may bring. But of the water-power existing on this planet there is a large proportion which has never yet been touched, and this, as well as the water-power which has been already forced into the bonds of man, runs on forever. This is of course an incalculable advantage over coal, which, by its use as fuel, is dissipated into the atmosphere in the shape of carbon dioxide and thus altogether destroyed as a source of energy, since from carbon dioxide fresh fuel can only be generated by the intervention of solar energy, and this takes place at such a very slow rate that it cannot be

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taken into account in our economical consideration.

We, who have been born to see the ascendency of coal as the principal producer of energy in bulk, can hardly realize what a short epoch in the past and future history of mankind belongs to the age of coal. It has taken many thousands of years to form the beds of coal which exist in the earth's crust, and which have preserved to us a tiny portion of the solar energy radiated upon our planet during that period, millions of years ago. At that period, for various reasons, the production of living matter must have been incomparably more rapid than is the case at present. During untold ages this stored up energy was lying idle, hidden under the accumulations of the more recent geological formations, not merely up to the advent of man, but through nearly the whole of his history. Leaving aside the tens of thousands or (according to some) hundreds of thousands of years during which man existed before the dawn of history, we must remember that historical documents exist in Egypt, Babylon, India, and elsewhere, taking us back at least 8,000 years, and that the most glorious times of Greek and Roman civilization are about 2,000 years behind us. How modern, in view of these figures, is the use of the coal, and over what a short time it will extend! In these isles the use of coal is much older than in any other country, but even here its serious exploitation is comparatively recent, dating barely 150 years back; whilst its future (even if we disregard the more pessimistic estimates) is not likely to exceed some 200, or at most 300, years. Germany and the United States will probably hold out 200 or 300 years longer, but in all other countries the chances are all the other way.

Well, what is to happen then? Those countries where water power is abundant may possibly substitute electrical heating for that produced by the burning of coal, but what about England and Germany, which are so poorly off in that respect? Even in those countries which are more favored the amount of water power is by no means infinite; and, if it had to be drawn upon, not merely for motive purposes, but for the production of electricity for heating purposes, it would be found insufficient in most places. Here we are faced by one of the greatest problems of applied science, both in chemistry and in physics, a problem which will give plenty of occupation to generations of future inventors. At present we can only surmise that some solution will present itself in the shape of a direct conversion of the sun's rays into other forms of energy; but the means by which this would be practically accomplished are at present quite uncertain.

The age of coal, in the midst of which we are living, short as it is evidently doomed to be in the long history of mankind, has been of incalculable service. For our purposes we may dismiss the earlier part of it, and look back only a hundred years. In all branches of industry, in locomotion, in the means of communication, and in innumerable matters ministering to the comforts of life, the progress since that time has been going on at a geometrical ratio. The present state of all these factors of civilization in Europe (to say nothing of America) differs from that obtaining a hundred years ago far more than the latter differed from the Roman Era, or even from the age of the Egyptian kings. And this miracle has been brought about solely by coal, without the aid of which it is simply impossible to imagine the revolution which has taken place since then. "Railways!" That single word, to give only one instance, will bring this home to anyone who ponders over this matter. And it is equally impossible for us to imagine that, during the past century, there could have been any other invention, based upon the utilization of the other supplies of energy of which we have spoken, which could have replaced the untold services of coal, that accumulator of solar energy, which alone has enabled the human mind to work out the thousand and one channels through which modern civilized life is flowing. We may say this with all confidence, for how otherwise could we account for the fact that such inventions have not been made in former times, when there were certainly quite as many ingenious minds in the world as during the coal-consuming age?

Let us now come down to considerations of a more modest, but more practical nature than those in which we have just been indulging. Seeing that the stock of mineral fuel upon this earth is so very limited, cannot we find means of husbanding it more than this has been done hitherto? It is only too notorious that the way in which coal is at present consumed is most wasteful. Of the energy residing in coal, most ordinary steam-engines utilize less than 10% by converting it into mechanical motion; and even the most perfect steam-engines devised utilize hardly more than 15%. Improvements in this direction

may possibly swell this proportion a little, but there is no prospect of gaining much in that direction. Enormous wastages are also incurred in other ways. The conversion of pig-iron into steel, the manufacture of glass and many other industries consumes from four to twenty times, and even more, of the quantity of coal required by theory. Many descriptions of coal are too poor to be used at all, except in the immediate vicinity of the spot where they occur; and in burning our fuel, whether it be for industrial or for technical purposes, we invariably send its nitrogen into the atmosphere, which surely contains quite enough of that commodity: the only exception being the manufacture of coal-gas, to which we shall refer later on. Here some of the grandest problems of applied chemistry present themselves to us—how to stop that fearful waste of fuel; and how to recover the nitrogen of the coal, if that be possible.

It is certain that we must look for the solution of these questions in the direction of converting coal into gaseous fuel. It is true that much has been done in that field in past years, and more especially will the name "Siemens" occur to every one in this connection, but much more remains to be accomplished. Another great stride ahead lies in the better utilization of the waste gases from blast furnaces, in which respect the last few years have witnessed some very important improvements. All this refers merely to a better utilization of the heating power of coal, but not to that other great task, the recovery of is nitrogen in a useful shape. This, together with the question how coal of poor quality is to be turned to a better account, has been tackled by the equally indefatigable and intelligently directed energy of Dr. Ludwig Mond, one of the benefactors of the Royal Institution. His invention, the "power-gas," has already attained a large measure of success, as is proved by the extent of the plants erected and designed. Mond's process belongs to that class by which we approach one of the greatest problems, for the time being, of applied chemistry, I mean the conversion of nitrogen from sources not yet opened out into ammonia and nitrates.

The immense importance of this latter problem lies in the fact that it touches our most urgent want, our supply of food. The soil of most countries, [illegible] in the old manner, would not [illegible] the production of the [illegible] food for men and cattle, while the [illegible] of its producing ca- are being gradually narrowed down by exhaustion. The importation of foodstuffs from other less thickly populated countries can only modify, but not altogether extinguish, the danger of ultimate shortness of food at some future date, possibly not so very remote. It is certainly a great comfort to know that, with suitable manuring, the soil may be forced to yield even better crops than it would give in the virgin state, let alone in a condition impoverished by centuries of tilling. But stable manure is nothing like sufficient to attain that object, and we must turn to mineral fertilizers, principally phosphates, potassium salts, and nitrogen compounds. The two former classes of fertilizers are found in abundance in nature, and there is no danger apparently of their being exhausted during the next thousand years.

But the case is very different with the mineral forms of nitrogenous manures, i. e., ammonium salts and nitrates. For agricultural purposes it does not make much difference whether we apply the nitrogen in one or the other of these forms. The ammonia, apart from insignificant quantities otherwise obtained, all comes from the nitrogen of the coal, but up to about twenty years ago only that coal which was used in the manufacture of gas was made to yield ammonia, and only one-sixth of its nitrogen was obtained in this form. In all other uses of coal, where at least twenty times as much is consumed as in the manufacture of gas, the nitrogen was simply sent into the air.

Quite recently some progress has been made in the way of utilizing some of this nitrogen as well. I have already mentioned the Mond process, where some of the nitrogen is recovered in the shape of ammonia; but this covers only one corner of the field. In another section a good deal has been already achieved. In the manufacture of coke, which is also a process of destructive distillation, and entirely analogous to gas making, very much larger quantities of coal are consumed than for the latter, since coke is indispensable for the smelting of iron and for other metallurgical purposes. Up to about twenty years ago all the volatile by-products in the manufacture of coke were lost—that is to say, tar, gas and ammonia. The recovery of these by-products was first carried through in one of two French coke-works, about 1861, but nowhere else for a number of years, although in 1879 the late Dr. R. Angus Smith had earnestly recommended to the English coke-works

of that system. Even now, both nd England as well as in America, y coke-ovens have found only a adoption; in England perhaps 5% is made in this way, against up-% in Germany. In consequence of twenty years ago Germany im-y all ammonium sulphate required ulture from this country, she now e, and has, on the contrary, be-e exporter of that commodity. The this wonderful change are various. m is undoubtedly the revival of f push and enterprise which, after nt for centuries in consequence of of the Thirty Years' War, caught nan people, and enlivened German all directions. Without going into his matter, we may take it that ble reserve of ammoniacal nitro-n the quarter indicated, and that production of about half a mil-f ammonium sulphate might be eased in that manner.

reserve is, after all, nothing like cover the requirements of agri-he future; and it is quite likely long run all the really available the coal would not suffice for the n. And what about the time when rill be exhausted? Well, there is nd inexhaustible source of nitro-h we must turn, and that is the air. Four-fifths of this consists calculated to amount to 4,000 bil-s, mixed with a quarter of that xygen. More than 100 years ago, Cavendish discovered the funda-that, by the action of the electric trogen of the air combines with orm nitric acid. The formation of om atmospheric nitrogen has also d, both by electricity and (which ortant) in other ways as well, as anon. But until a very few years acts have never been put to any e, and the problem of turning the nitrogen into ammonia, or nitric gh frequently approached in a ntific or, experimentally, in a y, had not been solved. Our days he realization of that most impor-

st speak of ammonia. We are led y what is, verily, a long and cir-. We must start from the dis-lcium carbide (announced in 1862 by the celebrated Woehler), the technical preparation of which substance was first effected by Wilson in 1892, and about the same time by Moissan. True, the expectations that were entertained in various quarters in connection with this remarkable chemical product have not been fully realized to the extent anticipated by the inventors; but, on the other hand, an entirely novel use has been discovered for it by Professor Adolf Frank and Dr. Caro, of Berlin. They found that when nitrogen is passed over red-hot calcium carbide it is absorbed with formation of calcium cyanide. This latter, when treated with water under high pressure, is made to yield ammonia; but it is not necessary to do this, since the crude product, which they have called "lime-nitrogen," can serve directly as nitrogenous fertilizer, and is in that respect equivalent to its own weight of ammonium sulphate. This is, indeed, its principal use for the present and the near future; but, as a matter of fact, the discoverers go much further. From the lime-nitrogen they prepare cyanogen derivatives of various kinds, some of which are valuable as constituents of explosives, and they are earnestly trying to employ it in the manufacture of nitric acid. They have also brought in several other industries—the manufacture of pure graphite, of pure hydrogen, of urea, and so forth. The pure nitrogen required for all this was at first produced by passing atmospheric air over red-hot copper; but it is now made by liquefying air and distilling off the oxygen, which is thus obtained as a valuable by-product. The inventors expressly recognize the invaluable aid which they have in this respect derived from the world-renowned researches of Sir James Dewar, carried out in the Royal Institution. The works already in operation, or in course of construction, will by the end of this year utilize water-power to the extent of some 55,000 HP., and will produce lime-nitrogen equivalent to 100,000 tons of nitrate of soda, and this with an expenditure of force less than one-third of that required for the process of Birkeland and Eyde, of which I shall speak directly.

I must, however, first say a word about the strenuous efforts made by Professor Frank and Dr. Caro, this time in connection with Dr. Ludwig Mond, to extract from peat both power and ammonia. Enormous, but hitherto almost worthless, deposits of peat exist in Ireland and North Germany; and the ultimate success of these endeavors, which we have

every reason to hope for, will prove an incalculable boon to these countries. At the same time, all fears of a scarcity of ammonia for agricultural purposes would be thus removed for generations to come.

Important as ammonia is as a fertilizer, it ranks after the nitrates in that respect; and, unlike ammonia, the nitrogen of the nitrates is of immense importance for other purposes as well, viz., the manufacture of nitric acid and of explosives. The very limited quantities of nitrates required in former times, amounting to a few tens of thousands of tons per annum, were furnished by Indian saltpetre, that is, crude potassium nitrate. A far more abundant supply was opened out a little more than half a century ago, when the exploitation of the beds of nitrate of soda in South America was begun. The crude nitrate found there is refined on the spot, and comes to us as "Chilian saltpetre," which is almost pure sodium nitrate, to the tune of a million and a half tons per annum. About four-fifths of this is taken up by agriculture, the remainder serving, in the first place, for the preparation of nitric acid. As for that acid, it is impossible to imagine how we could do without it. Apart from minor, but quite indispensable uses, one of which is in the manufacture of sulphuric acid by the lead-chamber process, the greater part of nitric acid is consumed in the manufacture of coal-tar colors and in that of explosives.

Let us pause for a minute to consider the last-named. Even supposing it possible that all wars could be abolished on this terrestrial globe—contingency not very likely to arise within the next few years, in spite of the laudable efforts of the Peace Societies—and that gunpowder were no longer required for shooting wild animals (an equally unlikely case, which would lead to a quite intolerable increase of game, big and otherwise)—we cannot conceive the possibility of our present system of civilization enduring without a colossal consumption of explosives. How could we carry on mining operations without them? How could we get stones from the quarries? How could we construct roads, and tunnels, and railways without the help of explosives, all of which have a basis of salts or esters of nitric acid? And these have, up to the present, been prepared almost exclusively from Chilian saltpetre. The idea has certainly been mooted to imitate the natural process by which the nitrate is formed in India. This has been tried during a number of years in France and in Sweden, but has been given up as unprofitable in our northern climes. Also, the interesting experiment of sowing the bacillus of nitrification and of cultivating it in the soil has proved a failure, although I would fain believe that the last word has not been spoken on that subject. This, if successful, would replace some of the nitrates now used as fertilizer, just as a better utilization of sewage would act in the same direction; but all this at the best goes only a very small way, and does not furnish the pure saltpetre required for the manufacture of nitric acid. What, then, shall we do when the nitre beds of Chili are exhausted? an event which, according to most estimates, is bound to take place within thirty or forty years from now. Unfortunately, there is no tangible hope of similar beds being found in any other localities, certainly not to any great extent. The beds of Atacama and Tarapaca on the Cordillera owe their origin to an altogether exceptional combination of climatic conditions and geological changes, the repetition of which in other quarters is exceedingly unlikely. Until very few years ago there was no prospect of any fresh supplies of nitrates in any other direction; but we may say that the solution of this problem, if not altogether settled in its final shape, has now been found. After many unsuccessful attempts at realizing for practical purposes the discovery of Cavendish, and after a thorough investigation of its scientific principles by Lord Rayleigh, Muthmann and Hofer, Nernst, Haber, and others, this has been achieved, and once more, by means of that well-nigh omnipotent agent, electricity, which thus renders yet another service to mankind. At Notodden, in the Norwegian Hitterdal, a factory has been established to carry out the process of Birkeland and Eyde, who, by an ingenious application of the extreme heat produced by the electric current, make the nitrogen and oxygen of air combine to nitric oxide, which at a lower temperature is spontaneously oxidized into nitrous vapors, with the ultimate production of nitrites or nitrates. This time there is really no doubt that a practical and economical process has been discovered for which it is intended to employ, by the end of this year, water power to the extent of 30,000 HP. The Notodden process bids fair to be followed by other even more efficient processes. The most important of these is that of the Badische Anilin and Soda-Fabrik, for which an experimental factory is in course of construction, and for which

)0 HP. are to be employed. But for some to come the Chilian saltpetre will still the trade; a very large amount of water r will, indeed, have to be brought into merely to cover the annual increment of ımption of this commodity for agricul- purposes.

ıe task it is certain that explosives will r fulfil, and that was suggested to me by of the cleverest mechanical engineers I known. He was intensely interested in problem of aerial navigation, and for this ose he wished to construct an engine ed by fuel of the most concentrated kind. ıer coal, nor benzine, nor oil would do. is plight he came to me and asked what sives I should advise him to try for ing his engine, in the erroneous idea explosives were a kind of concentrated Of course, I could not but reply as fol- : All honor to his courage, but no explo- known, so far ever or likely to be invent- could possess that property he required. a large store of energy. A pound of coal sents five times as much energy as a d of the strongest explosive known— ing gelatine. My friend had overlooked 'act that a pound of dynamite, though it out nearly 150,000,000 HP., does so only he space of 1/50,000 of a second. He had ted to take into account the element of and had confused power in the ordinary with energy, which is the capacity for work.

similar confusion is sometimes made be- n energy and the creation of high temper- es. This can be very well illustrated by use recently made of finely-powdered inum, both as a component of explosives as an agent for producing very high tem- tures, in the shape of Dr. Goldschmidt's rmite." In both cases the fact is utilized aluminum is easily, and in the shape of powder, almost instantaneously, convert- nto its oxide, alumina, by substances capa- of giving off oxygen. In the case of ther- , a mixture of finely-powdered aluminum ferric oxide is, when lighted, decomposed ntaneously into molten iron and alumi- oxide. The heat produced thereby far eds that produced by coal in any conceiv- way; it is equal to that of the electric arc. of the most important applications of this t occurs in the welding of the ends of rail- rails, when already laid down, into one inuous rail of any length required. And the total energy of thermite is only 450 mal units per kilogram, or in other words, about one-twentieth of that of the best coal. But, whereas it takes a good deal of time to burn a pound of coal, during which process there is a great loss of heat by radiation, and the heat is spread over a current of gases which we call the flame, a pound of thermite burns off in about one second, and, as there are no gaseous products formed, all the heat generated remains within the molten iron and alumina, which accounts for the extreme degree of heat to which these are brought.

Electricity has often been invoked to produce the most important of all inorganic products, iron. If this problem could ever be solved in an economical way, it would bring about a perfect revolution in the position of the leading nations. On the one hand, the enormous quantity of coal now consumed in the production of iron and steel (which is probably at least a quarter of the entire output of coal) would be set free for other uses, and the exhaustion of the coal-fields would be put off to a corresponding extent. On the other hand, the production of iron would pass over into the hands of those nations which command the largest amount of water-power, and which, therefore, can produce electricity most cheaply. Of the three countries which now produce between them the bulk, that is seven-eighths, of the world's iron, Great Britain and Germany would go to the wall, and the United States, which already produces more iron than these two countries put together, would become omnipotent in that field. Sweden, Italy, and some other countries would, at any rate, greatly increase their present production. But this radical change is, as yet, far off. No proof has, so far, been given that pig-iron, or the ordinary descriptions of wrought-iron and steel, can be generally produced by electricity at anything like the price at which it is now done by coal in the great industrial centers. Where a certain success has been scored in the electrical metallurgy of iron, it is for the refining of ordinary iron into a superior grade of steel which fetches an extraordinary high price, and in the production of certain alloys of iron with chromium, nickel, and the like, whereby so-called special steels are obtained. But if at the present moment we do not see our blast furnaces and Bessemer works threatened by the competition of electrical iron, who can tell how soon this may not be the case?

The limits of my time have been too nearly reached for me to discourse upon many other problems which present themselves in inor-

ganic applied chemistry, and only a few minutes are left to speak of those belonging to the domain of organic chemistry.

I will point to only two problems of this kind. One of these is the substitution of artificial for natural coloring matters. This, indeed, has now been carried out almost to the bitter end. Long ago, one of the oldest and most widely-used coloring matters, that contained in madder, succumbed to the attacks of the chemists, among whom the names of Edward Schunck and William Henry Perkin testify to the glorious share taken by Englishmen in that victory. The coloring substance of madder—alizarine—is now made from English coal-tar, and has altogether taken the place of the impure form in which it occurs in the madder plant. The growers of this plant in the south of France and elsewhere have had to abandon its culture altogether, to their great sorrow.

A similar fate has already partly overtaken, and may, in the end, destroy entirely, the culture of indigo, most of which, as you know, comes from British India, and formerly represented a value of some four million pounds sterling per annum. At first, after the great Munich chemist, Adolf Baeyer, had prepared the coloring matter of indigo by synthesis in his laboratory, the planters merely shrugged their shoulders, and that with good reason, since Baeyer's processes could not compete with their produce in respect of cost price. Another circumstance which at that time militated against artificial indigo was this, that it started from toluene, the total available quantity of which substance would not have sufficed for producing anything like all the indigo required, even if no toluene were used for other purposes, which is out of the question. But this state of matters has changed. Twelve years ago the late Carl Heumann, assistant professor in my laboratory at Zurich, discovered the synthesis of indigotine from naphthalene. This, like toluene, we get from coal-tar, but in about ten times the quantity, so that there is no fear of any scarcity of naphthalene even in the future. The late Dr. Rudolph Knietsch at the Badische Anilin und Sodafabrik at Ludwigshafen gradually transformed Heumann's laboratory process into a factory process, which is working with entire success on a large scale. Synthetic indigotine is now manufactured at such a low price that its competition has proved a severe blow to the indigo-planting interests. Thus the triumph of scientific investigation and practical skill in chemical manufacturing, gratifying though it be as a splendid achievement of applied chemistry, is a sad trial to many thousands of Indian ryots and their British masters; and this is merely the foretaste of what will inevitably happen in many other cases. What is food for one is poison for another.

Most other vegetable coloring matters, several of which have also been synthetically produced, have become useless by the discovery of hundreds, and even thousands, of artificial coloring matters far exceeding them in beauty, and often also in fastness. On this well-known point I cannot dwell now.

In conclusion, I would touch upon what is, perhaps, the very greatest problem of applied chemistry, and that is the direct production of feeding-stuffs for man and beast. The synthesis of alimentary substances from inorganic matter has, up to this moment, not been even remotely achieved, nor can we at present so much as guess the direction in which this might be done; whilst, as for the production of food from sawdust and other waste organic substances, we are in no better case. But even here the word "impossible" should not be pronounced. In a more modest form, at all events, chemistry has found magnificent scope in that quarter—I mean in the extraction of alimentary substances from new sources and in the increase of production from old ones. The colossal industry of beet-root sugar is an instance of the former, whilst agricultural chemistry, as a whole, works in the latter direction.

THE YIELD OF BLAST FURNACE GAS AND ITS CALORIFIC VALUE*

By PROFESSOR JOSEF VON EHRENWERTH

The increasing importance of the waste gases of the blast-furnace as an economic factor in iron-smelting, more particularly since their successful application in driving gas-engines, makes it necessary that closer control should be exercised in their disposal, for which purpose an easy and ready means of determining the total quantity available at any time is eminently desirable. The author therefore thinks that the following simple method of obtaining such a determination may be of interest to the members of the Institute. The data required by this method are:

1. The weight of carbon contained in the gases corresponding to any particular unit weight of make, say 100 kilograms.

2. An analysis of the gas expressing the constituents usually determined, in percentage volumes.

The first of these quantities, the carbon in the gases (C_g), corresponds to the total carbon (C_s) in the materials charged into the furnace, i. e., carbon in fuel and that in carbon dioxide contained in limestone flux or uncalcined carbonate ores, diminished by the amount (C_1) absorbed in carburizing the metal, and that (C_2) in unconsumed fuel carried away by the gas and intercepted in the dust-catcher, or:

$$C_g = C_s - (C_1 + C_2).$$

The total volume of the gases may be computed from the heat balance-sheet of the furnaces, where, however, they are expressed in weight, and no allowance is made for carbon in flue dust. An inquiry arising out of a practical matter for a directly applicable method of computation, applicable to all cases, has induced the author to publish this note.

The analyses of the gas should include determinations of carbonic acid, carbonic oxide, light and heavy hydro-carbons and nitrogen, together with hydrogen on account of its high specific volume, although the weight is usually unimportant. The calculation depends upon the simple proposition that the ratio of the volume of gas produced per unit of make to that of the analysis (100 volumes) is the same as that of the carbon contents of these quantities.

Supposing the analysis to show the constituents and their corresponding volumes to be—

$$aCO_2 + bCO + cCH_4 + dC_2H_4 + eH + fN = 100,$$

the carbon contained per 100 cubic meters in kilograms will be—

$$\tfrac{3}{11}\,1.978a + \tfrac{3}{7}\,1.252b + \tfrac{3}{4}\,0.559c + \tfrac{6}{7}\,1.16d = C_g$$
$$= 0.539a + 0.537b + 0.419c + 0.994d \quad = C_g$$

Or, in round numbers—

$$C_g = 0.54\,(a+b) + 0.42c + 1.00d.$$

The corresponding volumes of the different constituents per 100 units of make will then be found from the following proportions:—

For CO_2 in cu. m. ...... $C_0 : C_g = xCO_2 : a \quad xCO_2 = \dfrac{C_0}{C_g}a,$

" CO " ...... $C_0 : C_g = xCO : b \quad xCO = \dfrac{C_0}{C_g}b,$

and so on for the remaining constituents.

Or, in general—

Volume of gas in cubic meters per 100 units make

$$= \frac{C_0}{C_g}(a + b + c\ldots)$$

of the volumes per cent. by analysis.

In the same manner the total quantity of gas is given by—

$$G = \frac{C_0}{C_g}.100.$$

The results found by calculation are for the gas in the dried state, and require to be corrected for the water vapor derived from damp materials in the charge if necessary; and the volumes found are expressed at normal atmospheric pressure and a temperature of 0° C. For any other pressure, b_1 or temperature t, they become—

$$G^t_{b_1} = G^{0°}_{760m.} \cdot \frac{760}{b_1}(1 + \gamma t).$$

The calorific value per cubic meter at 0° C. and 760 mm. is—

*A paper read at the Vienna meeting of the Iron and Steel Institute.

$W = 30.63CO + 86.00CH_4 + 140.C_2H_4 + 26.2H$ calories, the gas being supposed to be free from water.

The following example illustrates the use of the method. A blast-furnace making white forge iron, with charcoal, from spathic ores (two-thirds calcined and one-third raw) consumed 74 kgs. of fuel per 100 kgs. of metal produced. What is the total volume of gas?

The charcoal contained—

C, 85.1; CO_2, 3.26; CO, 1.36; CH_4 0.7 per cent.; or carbon in 74 kgs.—

62·97 + 0·68 + 0·43 + 0.38 =	64·44 kgs.
Carbon of CO_2 in raw ore	4.54
Total carbon in materials charged C_a	68.98
Carbon in metal	3.12
Total carbon in gases	C_g 65.86

The gases contained—

CO_2, 15.3; CO, 25.6; CH_4, 0.7; H, 1.3; N, 57.1 volumes %; containing carbon 22.0 + 0.29 = 22.29 kgs. = C_g

$$\frac{65{\cdot}86}{22{\cdot}29} .100 = 295{\cdot}47 \text{ cubic meters per 100 kgs.,}$$

or 2,954·7 cubic meters = 104,350 cu. ft. per ton.

The calorific value is—

$(30.63 \times 25.6)) + (86 \times 0.7) + (26.2 \times 1.3) =$ 878 calories per cubic meter, or 98.4 British thermal units per cu. ft.

STEAM LOCOMOTIVES VS. ELECTRIC LOCOMOTIVES*

By MAX TOLTZ

The writer will show in the following that the steam locomotive properly improved is by far more economical than the electric locomotive, even taking it for granted that a kilowatt hour of electrical power could be furnished at the low figure of 0.6 ct. at the bus-bars and at 0.8 ct. effective for traction as named by Messrs. Stillwell and Putnam, who further state that a horse-power effective for traction will cost therefore 0.6 ct., of which 0.35 ct. is for fuel when coal of 14,000 B.T.U. per pound costs \$3 per ton of 2,240 pounds, and 0.25 ct. is for other power-house supplies, power-house labor and maintenance of power-house equipment.

To analyze these statements it will be necessary to first establish the cost of an effective locomotive HP. to be hereafter called drawbar HP. of the locomotive. From the figures given by the authors who estimate that for the operation of the entire freight and passenger service of the United States as existing in 1905, the aggregate energy required at the bus-bars of power-houses would approximate [illegible] 16,625,000,000 HP [illegible] statement, the [illegible] report of the Interstate Commerce Commission of 1904. The locomotives in service were in round numbers 47,000. The average freight locomotive is actually on the road not more than six hours in each twenty-four hour period and the same figure is approximately correct for the passenger locomotives. Assuming that each locomotive will develop during the six hours' work at every time 250 D. HP. (a very low estimate) the total number of HP.-hours per annum will then be nearly 26,000,000,000. In the reports of the Interstate Commerce Commission 1905, it is also stated that nearly \$156,500,000 were expended on fuel for locomotives. Dividing this item by the total HP.-hours per annum would give a cost of 0.6 ct. for fuel per D. HP. hour compared with the estimated cost of fuel of 0.35 ct., as above mentioned when assuming the railroads are operated electrically. This former figure is practically correct because we know that on the average a steam locomotive will use twenty-eight pounds of steam per HP. hour. The average coal used in a locomotive boiler will evaporate about 5 lbs. of water, which would necessitate 5.6 lbs. of coal per HP.-hour, at \$3 per ton of 2,240 pounds, amounting to 0.8 ct. per HP.-hour.

The question of the most economical work to be obtained from any locomotive seems to be not fully understood because the management of roads generally have prescribed the

*From a paper read before the [illegible]

policy of big train tonnage to the detriment of the service. The mechanical departments' recommendations regarding smaller tonnage and higher speeds are often not accepted and in consequence it will be found that the locomotives do not work to the best advantage.

Although a good deal has been said and written lately about the best train tonnage, it is within the province of the mechanical department of a railroad to establish such tonnage by computing the different data corresponding to the diagrams and the tests of the locomotives.

The basis of later calculation of the cost per draw-bar HP. will be made from data on the Mallet compound engine, with which the test performance is made at nine miles per hour on 2.2% grade, working with saturated steam, while with superheated steam it is at a speed a little over ten miles. Taking the first case, the increase of coal consumption over five miles per hour is only 8%, while the increase in ton-mile hours over five miles is 72%. At this speed the coal consumption per D. HP.-hour is 2.6 lbs.

This is a remarkable showing, but we should not be satisfied with the result obtained in this type of locomotive because more economy can be derived from further improvements, the main features of which will be referred to below.

Superheating.—During the last two years a successful attempt has been made to improve the steam by superheating, which not alone gives steam economy, but also saves the coal pile. Mr. Vaughan, of the Canadian Pacific, in his recent paper on superheated steam locomotives read before the American Society of Mechanical Engineers at Indianapolis, reported an average saving of coal at 15% with superheated over saturated steam locomotives, although in European practice these results average over 25%.

There is no doubt that this economical feature of steam engineering will be adopted and, with a little more vim and proper attention to the parts of the superheater, better results will unquestionably be obtained. Great credit should be given Herr Schmidt, who for the last ten years has done excellent work in this line in Europe, and the writer is fully convinced that in a few years, after the locomotive superheater has been adapted to and tried in our railroad practice, a greater economy in coal than has been shown so far will be recorded. Consequently, the saving in coal by the use of superheated instead of saturated steam will be assumed to be 20%.

Superheating in General.—If benefits are to be derived from superheated steam and results are to equal those obtained in Europe, it will be necessary to use highly superheated steam, that is, steam superheated not less than 250° F., and if possible over 300° F. But with the use of such highly superheated steam certain parts of the locomotive should be changed and a careful and positive lubrication should be arranged. Although so far, sight-feed lubricators have brought the oil to the proper place, the general tendency in the future will be towards positive feed, similar to that in stationary plants. The oil that is recommended by the Standard Oil Company is the Gargoyle-Hecle B, having a flashing point of 650° F.

Next to the saving in coal, by the use of superheated steam, comes the increase in the capacity of the boiler and the saving of feed water, which averages more than 30%. This feature is very important because in many instances a water station with exceptionally bad water can be abandoned or used for emergency. Boiler washings will be reduced and cost of water supply decreased proportionally.

Relatively lower or normal steam pressures can be reverted to, which will insure a longer life to the boiler and fire-box and will render easier the work of keeping the various joints and fittings steam-tight, besides greatly mitigating the stay bolts difficulty.

In consequence of lower pressures the cylinder diameter should be enlarged, and herein we can be guided by the experiments which were made with the superheated steam locomotives of the Prussian State Railway by Herr Robert Garbe, director of the mechanical department. In his recent book, "The Steam Locomotive of the Present," Garbe propounds an empirical formula of cylinder diameter for superheated locomotives, but does not explain how he arrived at it. The writer assumes that the diameter is proportioned to the average maximum tractive power to be desired. If this is the case, then the constant or coefficient is variable to the steam pressure admitted at the valves. According to Garbe this coefficient "C" ranges from 26 to 30 for steam pressures of 155 lbs. to 175 lbs., and the cylinder diameter can be figured from his formula, viz.:

$C = (d^2 l / DR) = 26$ to 30; in which

d = diameter of cylinder in centimeters.

l = stroke in centimeters.

D = driving-wheel diameter in centimeters.

R = weight on all drivers in metric tons (1 metric ton = 1.102 Eng. tons).

Transposing this into English measure the formula will be:

$C = (d^2l/DR) = 3.66$ to 4.23; $d = \sqrt{(CDR/l)}$; in which

d = diameter of cylinder in inches.

l = stroke in inches.

D = driving-wheel diameter in inches.

R = weight on all drivers in tons of 2,000 lbs.

In proportioning the cylinders of the locomotives of the Great Northern and Northern Pacific Railways, equipped with the Schmidt smoke flue superheater, the coefficient "C" was reduced according to pressure used, so that for a 200-lb. pressure, $C = 2.83$ to 3.28. This gave a cylinder diameter of 25¼ ins. for superheated, with an admission pressure of 165 lbs. against 22 ins. for superheated steam with 200 lbs. admission pressure, stroke 30 ins. The writer believes that the following values of "C" will work out satisfactorily for freight locomotives, taking in consideration a cut-off of 30%, viz.:

$C = 3.95$ for 155 lbs. admission pressure.

$C = 3.55$ for 175 lbs. admission pressure.

$C = 3.06$ for 200 lbs. admission pressure.

It is important to support the piston, not alone at one end by the cross head, but at the other end by a liberal bearing of the extended piston-rod, for the purpose of preventing the piston proper from riding on the cylinder wall, thereby decreasing friction to a minimum.

In order to overcome difficulties of lubrication with the use of highly superheated steam, slide-valves, on account of their large wearing surfaces, should not be employed. Piston-valves have given the best results.

On the Great Northern, as well as on the Northern Pacific engines, which were equipped with the Schmidt smoke-flue superheaters, the latter piston-valves were employed and have a diameter of 12 ins., while Herr Schmidt recommended 11 ins. only.

The poppet valve is best adapted for highly superheated steam, because it has a small wearing surface and is getting tighter the longer it is in service; besides, its location can be so arranged that the clearance is cut down to a minimum as with a Corliss valve.

Very little need be said about the piston rod packing. It is, of course, essential that such packing should stand the high heat of the steam. The writer found a composition of 80% antimony and 20% lead satisfactory.

Feed-Water Heaters.—Many designs of feed-water heaters have been proposed and tried on locomotives, but all have failed in one respect. After a short time the elements have been filled with the sediment or incrusting matters of the water, which flows through them. The writer tried two designs years ago, one in the fire-box and one in the smoke-box. The former was applied against the recommendations of the writer and the exit was exactly as expected; that is, after a short time it clogged up entirely and exploded, injuring the fireman. The latter heater gave so much trouble on account of filling up that it was abandoned.

During the last year a feed-water heater for locomotives has been tried on the Egyptian State Railroad, which heats the water in steps and utilizes partly steam from the main exhaust and partly the smoke-box gases. Instead of injectors a pump is employed, the exhaust of which gives the first step in heating, from which the water is forced into a second heater located on the right side of the engine above the cylinder and in which it is heated by a portion of the main exhaust. From here the water passes into a third heater on the opposite side of the engine, in which also a portion of the main exhaust is used; then flowing into the fourth heater which is located in the smoke-box, from which it is fed into the boiler. The water is heated in the different heaters to about the following temperatures, viz.: Leaving the pump at 90° F., the second heater at 180° F., the third heater at about 230° F., and the fourth heater at the final temperature of about 340° F. It is reported that the saving of coal with this arrangement on the locomotives of the above-mentioned railroad has been 20.4% in coal.

Smoke Consumers or Preventers.—The main point of perfect combustion of fuel is to admit the right quantity of air at the right place. Several devices have been brought forward, the latest of which is that of Mr. Timmis, of England, and which has been published in our engineering journals recently. By its construction a thin sheet of air is introduced above the fire at the back flue sheet, traveling in the opposite direction of the gases. The air which is blown in by a small fan has a slightly greater pressure than the draft above the fire. Mr. Timmis' device has been tried on English locomotives and it has been stated that besides getting smokeless combustion, it has saved coal to the extent of 15%. This may be possible, but it is generally conceded that in a locomotive not more than 10% of coal is wasted through the stack.

Hollow arches, one in front and one in the rear of the fire-box, are being applied to locomotives and are giving good results, but as

these arches have only a short life the cost of renewing them is quite an item.

There is no doubt that a considerable saving in coal can be obtained by getting perfect combustion, and for that reason the writer will employ for further calculations a factor of 5% in coal saving.

Boiler Repairs.—Of all locomotive repairs, about 40% are chargeable to the boiler, and it will be found that, due to the present design, the fire-box and the tubes need the most attention. By reverting to lower pressures in opposition to present practice and by changing the construction of the fire-box to that of a water tube design, the repairs can be minimized.

That there are great advantages in a water tube fire-box (stay-bolts being entirely done away with) there is no doubt, but it is only a question of simplifying such construction and testing it out and the writer believes that it is possible to design a water-tube fire-box which will reduce boiler repairs 75%. This means that the total locomotive repairs can be reduced 30%.

According to the statistics of railways for 1904, compiled by the Interstate Commerce Commission, the repairs and renewals of locomotives amounted to $115,000,000, while for engine and roundhouse men about $130,450,000 were expended. With improvements to boiler and to feed-water apparatus as outlined above, these items, in the opinion of the writer, could be reduced 30%, which would make a saving over $73,635,000.

Conclusions.—The writer has dealt with improvements to locomotives which in foreign practice have been successful and which, with slight changes, can be adapted to conditions on our railroads.

Although it is maintained that the work of the engine crew has been increased, due to the magnitude of the latest type of machine, so much that the limit of its capacity has been reached, it is believed, that by applying the above outlined improvements, the work of the crew will be decreased in many respects. For instance, in superheating the steam less coal will be handled by the fireman, and in connection with perfect lubrication, the work of the steam in the cylinders will be greatly improved. There should be no blown-out cylinder heads due to accumulation of water. Better and quicker starting of the train will be attained. Failures of non-steaming will be avoided by heating the feed-water. There will be fewer leaky flues and fire-boxes and the hard work of the fireman can be reduced considerably by a perfect stoker. Roundhouse labor on the boiler will be minimized, though the use of some coals, such as Illinois and Iowa, will require more attention to the cleaning of the smoke-flue superheater. Fire-boxes and flues will last longer, and last but not least, the curse of uncleanliness, due to locomotive smoke, will be abated under conditions of perfect combustion in the fire-box.

In making statements as to saving in the items of

(1) Repairs and renewals of locomotives,
(2) Engine and roundhouse men,
(3) Fuel for locomotives and
(4) Water supply for locomotives,

assuming that all locomotives are equipped with the aforesaid improvements, different propositions are computed.

As stated above, the saving in coal is to be figured at 20% by superheating, at 20% by feed-water heating, and at 5% by perfect combustion, an aggregate of 39.2%; the saving in locomotive repairs, items (1) and (2) 30%, the saving in water supply for locomotives, 30%.

The first proposition which naturally presents itself is to deduct from the items of the 1904 report of the Interstate Commerce Commission these various percentages, which will give the following results:

30% of $130,500,000 for engine and roundhouse men (2)....	$39,150,000
39.2% of $156,500,000 for locomotive fuel (3)............	61,348,000
30% of $9,150,000 for water supply (4)	2,745,000
Total saving per year......	$103,243,000

In this no account has been made for reduction of repairs and renewals, item (1).

The second proposition, assuming that all existing locomotives are of the latest types using, instead of 4¼ lbs., only 2.6 lbs. of coal per draw-bar HP., as stated above, and are equipped with the saving devices, will resolve itself into the following:

42.2% less coal for modern equipment	$66,040,000
39.2% of $90,460,000 (item 3) about	35,460,000
($90,460,000, $66,040,000, $156,500,000, total item 3)	
30% of $115,000,000 (item 1)..	
30% of $130,500,000 (item 2)..	73,635,000
30% of $9,150,000 (item 4)....	2,745,000
Total saving per year....	$177,880,000

It is estimated that the three improvements, viz.: superheater, feed-water heater and smoke-consumer or stoker, can be added at a cost of less than $4,000 per locomotive, which will make a total expenditure of $188,000,000 for 47,000 locomotives. According to propositions I and II this amount would be repaid within 22 months and 12.5 months respectively from the saving.

It is proper to repeat the statement made by Messrs. Stillwell and Putnam relative to the reduction of the four items referred to when all roads are electrically operated. They assumed a saving of

70% in item (1), Repairs and renewals of locomotives;
50% in item (2), Engine and roundhouse men;
50% in item (3), Fuel for locomotives, and
100% in item (4), Water supply for locomotives.

Accordingly, the savings would be as follows:

Item.

(1)—	70% of	$115,000,000...	$80,500,000
(2)—	50% of	130,500,000...	64,860,000
(3)—	50% of	156,500,000...	78,250,000
(4)—	100% of	9,148,000...	9,148,000
	A total of	....	$232,758,000

This, indeed, looks very attractive, but the writer leaves the criticism of these assumed figures to his brother engineers.

The amount of capital which must be expended to obtain these doubtful results can hardly be imagined. A conservative estimate would be several billions of dollars. Although the estimated savings by an electrical equipment might warrant such an immense expenditure, the improvement of the steam locomotive offers like inducements. It has been the boast of the advocates of railroad electrification that with an electric locomotive double the trailing tonnage can be hauled at double the speed of the present steam locomotive. The writer begs to state that the steam locomotive of today (and not the most powerful one yet built) takes 800 tons singly and 1,600 tons doubly over a mountain grade of 2.2% with a speed of ten miles per hour.

The electric locomotive, either in single or multiple units, has its place in big terminals and in tunnels, but it cannot in its present development replace the steam locomotive, for trunk-line service. The writer has investigated some of the greatest water powers in the Rockies and in the Cascades, and he ventures to say that none of them can deliver electrical power per draw-bar HP. per hour for less than 0.5 ct. Another feature over which most enthusiasts of electrification stumble is the high power factor which is assumed. If electrically operated today, the power factor would not exceed 48% on three typical American railroads: the Great Northern, Northern Pacific and Canadian Pacific.

NOTES ON LOW-PRESSURE STEAM TURBINES

By J. R. BIBBINS

CONDENSED FROM "THE ELECTRIC JOURNAL"

In view of the possible development of low-pressure steam turbine work, which seems probable, judging from present indications, a brief discussion of some of the important technical points involved may be of interest. First, consider how much energy is available in steam below atmospheric pressure; second, what percentage of this is transformed into work by the turbine; and third, what percentage by a good steam engine.

Operating between 15 lbs. absolute and 26 ins. vacuum, the steam consumption of a well-designed steam turbine should be under 35 lbs. per B. H.P.-hr. Now the heat energy released in adiabatic expansion between the above limits, is 113.7 B.T.U. per lb., or $113.7 \times 778 = 88,500$ ft.-lbs. For a steam consumption of 35 lbs. per HP.-hr., the steam thus supplies to the turbine 3,097,500 ft.-lbs. per hour. As one horse-power is equivalent to 1,980,000 ft.-lbs. per hour ($33,000 \times 60$), the turbine actually uses 63.9% of the available energy in the steam cycle. That these figures are conservative, is shown by the results of a series of tests recently made on the low-pressure section of the low-pressure half of a 1,250-KW., two-cylinder, Westinghouse-Parsons turbine. At full load, this machine showed a steam consumption, working between atmosphere and 28 ins. vacuum, of something less than 30 lbs. per B. HP.-hr.

Considering now the case of a compound reciprocating engine:—If well loaded, release occurs at from six to eight pounds absolute

pressure, even with a high vacuum. This creates a blunt "toe" on the low-pressure card, which is unavoidable, except with a very large low-pressure cylinder. But this increases very materially the friction, bulk and cost of the engine without very much ultimate gain from a practical standpoint. In fact, under a variable load, the triple-expansion engine may show no better economy than a compound. But the turbine can utilize low-pressure steam to so much greater advantage that it becomes desirable to run piston engines high pressure with low-pressure turbine between engine and condenser. Thus, the turbine acts as the third cylinder in a triple-expansion system, but at a much higher efficiency than possible with piston engines. Assuming two 1,250-I.HP. engines with a water rate of 21 lbs. per I.HP. hr., enough steam would be furnished at atmospheric pressure to operate a 1,500-HP. low-pressure turbine. This represents an increase in power for the same total steam consumption of 66%. If, on the other hand, the non-condensing engines were run condensing, without any change in cylinder ratio, not more than 20% increase in power would be realized with 15% decrease in water rate. Thus, for the same total steam consumption per hour in the two cases, this method of connecting the low-pressure turbine to non-condensing engines yields three times more additional power than is obtained by running the same compound engines condensing.

CASE-HARDENING*

By G. SHAW SCOTT, M. Sc.

Generally speaking, comparatively little is known of the theory of the process by those who practice the operation of case-hardening, and up to quite recent years crude rule-of-thumb methods were almost universally applied. The production of satisfactory case-hardened material is a matter of supreme importance to many engineering undertakings, and especially to cycle and motor-car making, in which there is often required very hard, yet tough, material in order to obtain satisfactory results in everyday use.

Case-hardening is fundamentally the same as the older process of cementation, the chief points of difference being that in case-hardening a different carbon-conveying material is used from that employed in cementation, whilst in the latter process the carbon is allowed to penetrate nearly through the bars and to form merely a surface or "case" of carburized metal.

Case-hardening is somewhat allied to the Harveyizing and Krupp processes, both of which are employed for the hardening of armor-plate. In the former process a solid carbonaceous cementing material is employed—usually charcoal; and in the latter a gaseous hydrocarbon is stated to replace the charcoal.

MATERIALS USED IN EXPERIMENTS.

For the purposes of this research a variety of steel was selected which has been found by experience in the trade to be especially suitable for case-hardening.

On analysis this steel was found to have the following composition:

Combined carbon	0.14	per cent.
Silicon	0.01	"
Sulphur	0.08	"
Phosphorus	0.03	"
Manganese	0.58	"
Iron (by difference)...	99.16	"
	100.00	"

The 3-ft. bars of ¼-in. rolled steel were cut up into 4-in. lengths and marked for reference.

Many case-hardening mixtures were tried, among them such materials as burnt leather (several varieties), wood charcoal, anthracite, sugar charcoal, mixtures of barium carbonate and wood charcoal, etc. Owing to its almost universal use in trade circles in England, burnt leather was employed as the standard case-hardening material throughout the research. Two samples of this material in particular were tested, both of which have a considerable sale; they are subsequently referred to as mixtures "A" and "B."

Since preliminary experiments showed that there was a difference in the case-hardening effect due to the relative fineness of the carbonizing material, samples "A" and "B" were sieved and the results are given below:

*Paper read at the Vienna meeting of the Iron and Steel Institute.

	"A" per cent.	"B" per cent.
Does not pass 10 sieve	68.0	72.6
" " 20 "	9.0	9.6
" " 30 "	4.2	5.8
" " 60 "	4.4	5.4
" " 90 "	4.0	3.8
Does pass 90 "	9.4	2.6
	99.0	99.8

Practically 75 per cent. of the material was comparatively coarse; and there was rather a high proportion of very fine material in "A" as compared with "B" Sample "B" was found to contain a considerable amount of unburnt, or only partially burnt, material, and this is a feature in a case-hardening material that does not tend to reliable work.

Estimations of moisture and ash were made of these mixtures with the following results:

	Moisture per cent.	Ash per cent.
"A"	13.44	5.56
"B"	24.68	3.60

The mixture "A" was decided on as standard, and an estimation of the amount of nitrogen present was made by Kjeldahl's method.

The composition of our standard case-hardening material "A" is as follows:

	per cent.
Carbon (by difference)	77.80
Nitrogen	3.20
Moisture	13.44
Ash	5.56
	100.00

For heating the experimental bars in contact with the case-hardening mixtures cast-iron boxes 4 ins. by 2 ins. by 1 in. by ¼-in. thick were used.

The muffles used were Morgan type, heated by Mond gas, and capable of giving a temperature of 1,000° C. The temperature of the muffles was recorded by means of a direct-reading Baird & Tatlock thermo-couple pyrometer.

INFLUENCE OF TEMPERATURE ON CASE-HARDENING.

The first experiments dealt with the influence of time and temperature upon carbon absorption, employing the standard mixture "A." In connection with case-hardening temperatures, it may be pointed out that Mr Osmond's work has shown that the lowest practicable temperature, using pure iron and pure carbon, will be not much below 900° C., a statement which was checked as follows: Bars were heated for four hours at 700° C. in "A," and subsequent microscopic examination showed that absolutely no carbon penetration had taken place. A penetration—to the depth of 0.13 mm.—was observed after similar treatment at 800° C., while at 900° C. the depth of carbon impregnation had increased to 1.58 mm.

At 1,000° C. the depth of penetration was found to be more than twice that obtained by case-hardening at 900° C. for an equal length of time. At temperatures higher than 900° C. the danger of overheating the metal was evidenced, and the carbon absorption become both "harsh" and irregular. For normal case-hardening a "case" should be obtained which contains a percentage of carbon equal to that of the pearlite eutectoid—namely 0.89%. With more carbon the "case" in its "normal" or unhardened condition shows cementite as white rivers surrounding the larger masses of pearlite.

The specimen represented having been heated in mixture "B" for eight hours at 1,000° C. showed the presence of much cementite, which is generally regarded as unsatisfactory in case-hardened articles.

INFLUENCE OF TIME AND CEMENTING MATERIAL ON CASE-HARDENING.

Having briefly considered the effect of various temperatures upon the depth of carbon penetration when using a standard case-hardening mixture, the author proceeds to consider the effects of the use of various mixtures for differing periods of time, the uniform temperature of 900° C. being employed throughout the series.

Using specimens 3 ins. long and 6.5 mms. square section, the following figures were obtained:

Time of Heating	Burnt Leather "A"	Wood Charcoal	Barium Carbonate' and Wood Charcoal
2 hours	1.15 mm.	0.72 mm.	0.36 mm.
4 "	1.58 mm.	1.07 mm.	2.20 mm.
8 "	2.30 mm.	1.58 mm.	2.84 mm.
12 "	2.80 mm.	1.80 mm.	3.17 mm.
16 "	Right across specimen.		

From these results it will be seen that the most rapid penetration took place when using the mixture of barium carbonate and wood charcoal, while the least penetration resulted from the use of wood charcoal. However, when the heat was sufficiently prolonged, the several mixtures gave approximately the same results.

CASE-HARDENING MATERIALS.

These are very varied in character, and include wood charcoal, potassium, ferro-cyanide, potassium cyanide, petroleum, gas, bone, horn, graphite, burnt leather, bone black, acetylene, barium carbonate and charcoal, coal gas, sugar charcoal, etc. What is most noteworthy in connection with this list is that of all the materials mentioned those that give the most rapid case-hardening effect are those which either contain nitrogen in some form or other, or else have the power of utilizing atmospheric nitrogen.

NITROGEN AND CASE-HARDENING.

The case-hardening materials in common commercial use contain nitrogen. It is obvious that unless practical experience had shown that nitrogen aided the process in some way, no one would think of using a costly nitrogenous material in place of charcoal or anthracite, these being well-known possible substitutes which cost only as much per ton as burnt leather costs per cwt.

To prove how slight was the effect (measured by carbon penetration) of heating the standard steel bar with materials other than those which contain, or supply, nitrogen, experiments were made with anthracite, and also hard coke. The carbonaceous material in each case, together with the bar to be treated, was packed gently in one of the special iron boxes, carefully luted down, and heated in a muffle for four hours at 900° C. After this heating it was found that there was penetration to the following extent:

a Anthracite.....0.15 mm. on 6.5-mm. bar
b Best hard coke.0.16 mm. on 6.5-mm. bar

With a bar under exactly similar conditions, but using as a carbonizing material burnt leather "A" instead of the above, a penetration of 1.58 mm. was obtained. From this it will be seen that the effect of the nitrogenous mixture was to increase the depth of penetration during the initial stage of case-hardening in the ratio of about ten to one. Hence it will be recognized that nitrogen must play a very important part in the process of case-hardening. Experiments were undertaken to test this, and resulted as follows:

Two exactly similar bars of standard steel were selected. One was heated in an atmosphere of ammonia for four hours at 550° C. The other received no treatment. Afterwards, both were heated in separate cast-iron boxes in a non-nitrogenous carbonaceous material (sugar carbon) for eight hours at 1,000° C. The mean figures of a series of these experiments showed that the "ammonia bar," as compared with the untreated bar, had received greater proportionate penetration in the ratio of 45 to 32. The high temperature employed was specially favorable to the non-nitrogenous material, and had the heating been conducted at a lower temperature, the difference would, in all probability, have been still greater.

Subsequently an apparatus was made to pass dry ammonia into the case-hardening box during the whole period of heating in the muffle. For this purpose one extremity of a piece of ½-in. gas-pipe was screwed into the end of one of the boxes. The other extremity projected outside the muffle and was connected to an apparatus for giving dry ammonia.

In the same muffle as the above box, and placed side by side with it, was an ordinary box. Both were filled with sugar charcoal as a non-nitrogenous carbonizing medium, and among the charcoal several test-bars were placed.

The muffle containing the two boxes was kept at 900° C. for four hours; a stream of ammonia being passed through the special box, escaping through a minute hole drilled in the lid. Afterwards the boxes were allowed to cool, ammonia still passing into the special box. On subsequent superficial examination the "non-ammonia" specimens were found to be bluish-black in color and quite soft to the saw. On the other hand, all the ammonia-treated bars possessed a distinct whitish luster, and presented a tough outer skin to the saw. Microscopic examination showed that whereas the bars which had received no ammonia treatment gave a penetration figure of 1.44 mm., those which had been treated with the gas had been penetrated by the carbon to the extent of 1.80 mm.

It will be seen that ammonia did cause a slight increase of carbon penetration.

"TWINNING" RESULTING FROM AMMONIA TREATMENT OF BARS.

Mention is made of the peculiar results obtained by heating bars at a certain temperature in ammonia. After treatment with ammonia for four hours at 550° C. the bars showed a bright, silvery luster, and on microscopic examination, a structure at the edge of each specimen was observed which showed very obvious "twinning." Photographs showed these twin-crystal areas, one photo demon-

strating the strong resemblance of parts of the structure to that of a bar of worked copper.

That twin crystals were not present in the bars before treatment was proved by repeated and careful microscopic examination at high powers of the original material.

A uniform structure was always observed right through the bar. To show that the "twinning" was not produced by the distortion of the bar by mechanical strain, a bar was held in the vise and bent backwards and forwards several times until fracture occurred. No twin crystals resulted from this treatment, or from other tests. It is therefore evident that these twin crystals were not present in the original steel, nor were they induced by any subsequent mechanical treatment, but that they were produced by heating the bars for a more or less prolonged period at 550° C. in an atmosphere of ammonia.

THEORY OF CASE-HARDENING IN PRESENCE OF NITROGEN.

It appears to be clear that nitrogen in some form is necessary for the practical performance of case-hardening, and the question therefore arises as to the manner in which nitrogen assists the rate of carburization. That the free gas itself has no effect upon steel has been proved both by Guillet and by Braune. Ammonia, on the other hand, is absorbed by iron, and the experiments above recorded prove that it causes an increase in the rate of carburization when carbonaceous material is present. This latter fact suggests that ammonia itself, while being the prime agent in any change, may conceivably lead to the formation of cyanogen, and that this cyanogen may act upon the iron thus:

$$2CN+3Fe_2=2Fe_3C+2N$$

from which it will be seen that the cyanogen may act as a carrier of carbon to the metal to be carburized.

This, however, does not explain why carburization takes place at a lower temperature when nitrogen compounds are present. But it has been shown that after steel has been heated in ammonia "twinning" is observed. Now, since Osmond has shown that twinning can only result when iron or steel is in the γ condition, it is reasonable to assume that the metal has been changed from the α to the γ state. Under normal conditions, metal at 550° C. would certainly be in the α condition. Nitrogen, we may conclude, should therefore be added to the list of elements which cause iron to take or retain the γ form. And, since γ-iron combines more readily with carbon than does α-iron, this action of nitrogen, on the iron, would appear to explain sufficiently its beneficial effect during the early stages of the process of case-hardening.

AERIAL RAILWAY FOR USE IN FILLING SOFT GROUND

The line of the Lake Erie & Pittsburg Railroad crosses a swampy piece of ground about 25 miles south of Cleveland. In making the fill it was found that trestlework was impracticable on account of the inability of the soft ground to sustain any considerable weight. Recourse was had to a suspended cable construction, one end of which is shown in the illustration. Two 1¾-in. steel cables are strung across the soft ground, anchored at their ends and [illegible] by means [illegible] Wooden ties are fixed [illegible] to the cables with ⅝-in. U-bolts and to these the rails are fastened. A train of seven 4-yd. cars, weighing about 48 tons, is run out on the suspended track and dumped. About

VIEW OF CABLE-SUSPENDED TRACK SHOWING DUMP-CAR TRAIN.

40,000 cu. yds. are handled in one month, the best day's work being 104 4-yd. cars.

WORKING UP OLD PRINTED PAPER

FROM "PAPER MAKING," LONDON

Used printed paper and paper cuttings have now an important place among the raw materials of paper manufacture. So much is this the case that large establishments exist for sorting purposes only, and many middlemen occupy themselves entirely with paper-scraps, printed or otherwise.

The chief points to be borne in mind in working up waste printed papers, is, that the new paper must be at least as good as the original paper, i.e., capable of being used as that paper was, that no special plant should be needed, and that the cost of the process should not be prohibitive. If these conditions are fulfilled there is no reason why the same cellulose should not be converted into paper many times over. There must of course be an end to this economical procedure, when the fibers are broken up so much that they cannot form a web.

The chief difficulty in the way of obtaining a usable pulp from printed papers is presented by the printing ink, and means have therefore to be sought of getting rid of this substance. The indelibility of printing ink is proverbial, but although it cannot be removed without disintegrating the paper, it can be removed after or during that disintegration.

Taking the chief sort of printed paper, viz.: old newspapers, we find an inferior paper made of wood-pulp, cellulose and fillings. The printing on it may be regarded as the result of the drying of a mixture of finely divided lampblack with an oily vehicle. On examining a printed letter under a high power, the black particles of lampblack and the gray dry residue of the vehicle can often be clearly differentiated.

The principle which underlies the removal of printing ink from paper is thus obviously to employ agents which will destroy or dissolve the vehicle which binds the lampblack, or other pigment (colored printing inks are now in extensive use), to the paper.

The first step is to tear up and disintegrate the waste paper in the ordinary manner. The resulting pulp is sieved, and it will be found that while the fiber remains on the sieve almost entirely, a fine sieve being of course used, a large part of the pigment which has been mechanically loosened from the fiber during the disintegration of the same passes through, together with much of the binding vehicle and nearly all the weighting and filling bodies present in the original paper. This, of course, much facilitates the subsequent treatment, as the pulp from the sieve is already partly freed from ink and other foreign bodies. One process to which it may be subjected is that of Knopf (German patent 127,820). This inventor treats the pulp from the sieve with soap-solution. It is then sieved again, and the soap carries most of the remaining pigment, which it has loosened from the fiber, through the sieve. The amount of soap required naturally varies within wide limits, i.e., from 3 to 22% of the weight of the waste paper, according to the character of the paper, and the nature and amount of the printing ink present. The pulp on the sieve is rinsed free from the excess of soap with water. It is essential to work the process throughout without artificial heat, especially when it is a question of cheap printing inks made from rosin oil. Heat would induce oxidation of the vehicle, and enable it to resist the solvent action of the soap.

Such a process entails loss of finely divided fiber during sieving, and the conversion of the vehicle and filling into a lye or emulsion which will not only escape through the sieve but carry the pigment with it, is never complete, so that the best result is a pulp of a decidedly doubtful white. The loss of fiber is often a very serious item, and sufficient of itself to make the process unremunerative. On the whole the best procedure is Knopf's, using two sieves, one below the other, and both as fine as possible. In this way, the nearest approach to a white pulp which can be got with a lamp-blank ink is secured. The second sieve saves much waste of fiber.

In conclusion, it should be noted that these remarks are concerned with lampblack ink only. Many of the colored printing inks now in vogue are easily destroyed by bleaching agents without any injury to the paper-fiber.

VIEWS OF THE QUEBEC BRIDGE WRECK

(SUPPLEMENTING THOSE IN SEPTEMBER TECHNICAL LITERATURE)

VIEW ALONG THE EAST SIDE OF WRECK.

VIEW LOOKING NORTH, TOWARDS MAIN PIER.

ANOTHER VIEW ALONG THE EAST SIDE OF WRECK.

DETAIL VIEW OF THE BUCKLED BOTTOM CHORD A9L.

LUBRICATING OILS

By J. H. COSTE and E. T. SHELBOURN

CONDENSED FROM "PUBLIC WORKS," LONDON

The very varied requirements of modern machinery have rendered the question of lubrication and lubricants one of the greatest importance to engineers, while the examination of lubricants forms an important branch of the analytical chemist's work.

The word lubricant is derived from the Latin lubricus—slippery—a word which very well expresses our popular conception of a lubricant—a thing which, adding slipperiness to rubbing surfaces, causes them to move over one another easily.

Were it not for friction or loss of energy caused by the rubbing of surfaces together, motion once imparted to a body would continue for ever; as it is, however, an appalling amount of energy is consumed in all mechanical contrivances in overcoming friction. Friction, like most properties of matter, has its useful side—belt-driving, the rolling motion of all self-propelling vehicles, most brakes for stopping machinery, screw-propellers, and many such devices would be impossible were it not for friction. It is, however, and must, from the earliest application of such a simple means of economizing power as the wheel, have been an aim to reduce the friction between working parts of a machine to a minimum. It may be of interest to quote a statement made by Prof. Goodman as to the loss of power due to friction.

"Out of every ton of coal consumed for engine purposes some 400 lbs. to 800 lbs. are wasted in overcoming the friction of the working parts of the motor; and, further, every machine driven by a motor also wastes a large percentage of the remaining power by its own friction. One would not be far short of the mark in saying that from 40 to 80% of the fuel is consumed in overcoming friction. This extremely wasteful state of affairs is most unsatisfactory, and happily can be greatly improved by a due observance of the laws of friction and lubrication."

THE THEORY OF FRICTION.

We know that if two solid plane surfaces are placed in contact it requires a perceptible amount of force to slide one over the other, even in a case where the surfaces are, to the eye, absolutely smooth; we know, however, that such a thing as an absolutely smooth surface is impossible—the smoothest surfaces are really slightly serrated or irregular, and it is conceivable that friction is due to interlocking of these irregularities.

That friction increases with the load causing contacts occurring between sliding or a well-known fact. It is for sliding surfaces approximately proportional to the load. Now if some device could be adopted for preventing contacts occurring between sliding or rolling surfaces, the loss of energy, heating and consequent wear could be very much reduced. The device usually adopted is that of interposing a third substance which is of such a nature as easily to accommodate itself to the shape and area of the surfaces in question, and the friction between the particles of which is so small that these particles will freely move over each other.

Let us consider what this means. An ordinary solid, like a block of steel, cannot easily be altered in shape; great pressure, continued impact or intense heat are necessary to alter its form. It is an excellent material for making rubbing surfaces of, but not a suitable material for lubricating them, because its particles possess such great mutual attraction that they will not easily roll over one another. Nevertheless, steel is used in a somewhat similar manner to that of which we are speaking. In the bicycle ball-bearing very true spheres of steel by their rolling reduce the friction which would occur between rubbing bearings. Now suppose we have a great number of such steel balls or of shot, they will, as you know, easily accommodate themselves to the shape of any vessel in which they are poured, in fact, their behavior suggests that of a fluid. It is indeed a suitable fluid which we want to introduce between our rubbing surfaces—a substance the millions of particles of which will so easily roll over each other that, like the shot, they will

ıp the shape of any vessel in which they laced.

ınting for the time that an ideal lubri- s to be a fluid let us consider what sort ld it is to be. When we consider the e of fluids we see than our analogy of balls or shot begins to break down. is a cohesion between the particles of d of a different nature from that be- the shot. Fluids form skins, so to , on their surface, and according to the ve amount of surface tension, as this ncy is called, have greater or less at- on for the surfaces with which they are ntact. Mercury, for example, will not e to the surface of glass to such an ex- as to "wet" it, although there is suffi- attraction between mercury and glass event the passage of air between them e case of a barometer. There are, how- some surfaces to which mercury will ad- In the case of glass, wood, steel or enware, the surface tension of mercury is uch greater that it will stand off with x edges, even forming globules in small ities. Other liquids have such low sur- tensions and low internal friction that will almost immediately spread over a ce on which they are dropped, such as ntine, water, alcohol. These liquids, from their easy volatility, are, owing to small internal friction and low surface n, unsuitable for lubrication. They l not keep the surfaces sufficiently apart event them rubbing, and they would d beyond the rubbing parts. At first it would appear that the lower the fric- of the particles of the lubricant the bet- would be; but this shows it is not so, in as will be seen, thickening agents are imes added to lubricants to increase natural internal friction. The internal on of liquids is so very small compared that of solids that the most viscous would, if in other respects suitable, lub- solid rubbing surfaces. We have just use of the term "viscous." Viscosity is ame applied to this internal friction of which we have been considering. It is sary that liquid lubricants should, be- possessing suitable viscosity and sur- tension, be so "oily" that they will keep ıbricated surfaces sufficiently apart. For ple, glycerine is a very viscous liquid. s of little use as a lubricant, because the formed between surfaces may be so thin that efficient separation is not maintained. Oils vary very much in this respect. Animal oils are the most oily—that is, form the thickest minimum films—vegetable oils less so, mineral oils still less so. To an extent this property follows that of viscosity.

Having briefly considered the theoretical aspect of lubrication, we will premise that the requirements of machinery are very varied. Lubricants are required for both high- and low-speed machinery, for rubbing and for rolling surfaces, for very different pressures, for different temperatures, both local, as in parts of an engine, and climatic, and for work under varied atmospheric conditions as in air, in steam of varying temperatures, in incandescent gas, as in a gas-engine cylinder. This being so, it is fortunate that we have a very wide range of materials from which to choose.

Before considering the nature of oils used for lubricating purposes, it may be well to consider certain features which would be objectionable in oils intended for these purposes.

Obviously the first class of constituents to which objection would be raised includes those which would reduce lubrication, assuming viscosity to be suitable. They are (a) constituents mechanically reducing lubrication, as hard solid particles of sand, metal, metallic oxides, etc.; these could be removed by filtration; (b) constituents which reduce lubrication by "gumming" or oxidation into more or less varnish-like masses, such as are obtained by oxidation of "drying" oils; (c) constituents which reduce lubrication by carbonizing or "charring" (this occurs only in oils used for high-temperature cylinders, but sometimes causes much trouble owing to the formation of considerable masses of solid carbon); (d) constituents causing chemical erosion of rubbing surfaces, as free fatty or mineral acids (the latter having been used in purifying the oil).

Another highly objectionable and dangerous class of constituents are those of such a volatile and inflammable nature that the oil is liable to "flash" at the temperature at which it is being used when a light is brought near it. These constituents also from their low viscosity reduce the original viscosity of the oil, which viscosity will increase, perhaps to an objectionable extent, as heat causes them to evaporate.

QUALITIES OF GOOD LUBRICANTS.

We find, then, that a suitable lubricant should be:—

(1) Of a proper consistency to feed well with the lubricating arrangements and under the temperature conditions required.
(2) Of such viscosity and "oiliness" as to reduce friction to a minimum.
(3) Contain a minimum amount of constituents prejudicial to its sustained effect.
(4) Safe in use.

These requirements indicate somewhat the lines on which the examinations of lubricants have to be conducted.

In the first place inspection will show, in the case of clear liquids, whether any solid particles are present. If the oil is not sufficiently clear for this, filtration through porour (filter) paper, linen or very fine wire gauze will separate such particles, which may be freed from oil with ether and examined. If of a hard and gritty nature the lubricant is obviously unsuitable for use without sedimentation or filtration.

The presence of constituents which cause "gumming" can be detected by exposing thin layers of oil to an elevated temperature for some hours and noting whether any "thickening" or formation of a skin has occurred.

Carbonization or "charring," which sometimes occurs in high-temperature cylinders, is probably due to the repeated use of oil containing fatty matter, (saponifiable oil) or to overheating, due to insufficient supply of lubricant. Where trouble of this kind has occurred, tests could be made with lubricants proposed for use by keeping them at a suitable elevated temperature for some days and then examining by dilution with a light solvent, as ether, and settlement of any solid particles which had formed.

Free fatty acids, resin, or mineral acids can be easily detected, and their amount and nature determined by neutralization with an alkaline solution of known strength, and by certain qualitative tests. Volatile constituents of an inflammable nature can be detected by determination of the flashing point, either in an open cup or in a standard form of apparatus such as the Pensky Marten.

This apparatus consists of a brass cup which fits loosely into a cast-iron body, over which rests a dome-shaped brass shield. The cup is closed by means of a close-fitting lid having a perforated revolving slide actuated by means of a spring lever. By turning the lever the openings in the slide are made to coincide with corresponding holes in the lid, and a small flame at the same time dips through the central opening into the space above the oil in the cup, igniting the vapor as soon as the flash-point is reached. Through the center of the lid a stirrer passes, consisting of four vanes, two for mixing the vapor and two for the oil. A thermometer passed through the lid gives the temperature at which the flash takes place. The whole is mounted on a tripod and heated by means of a bunsen burner.

The total loss on heating for two hours to the temperature of boiling water affords a good criterion of the total amount of "volatile matter"—that is to say, of matter which will probably be lost by evaporation in working the lubricant.

The suitability of the consistency of a lubricant at ordinary and low temperatures considered in reference to the question of feeding can be determined by means of the melting or solidifying point in the case of a grease or of an oil for warm climates, or by means of a fluidity test at a low temperature—i. e., ascertaining at what temperature the oil ceases to flow on cooling in a freezing mixture. Ordinary "machinery" and "cylinder" oils should not cease to flow when cooled to a temperature of 25° F.—this test indicates the absence of any noticeable amount of solid paraffin.

Viscosity is determined in an instrument called a "viscometer." This is usually simply a vessel which can be filled to a standard height, with a hole of standard size in the bottom and a standard measure for the fluid to flow into. The number of seconds required to fill this vessel when the oil is flowing at a given temperature through the hole, having started from the standard level, is the figure usually recorded. Heating apparatus is arranged for the viscometer in the form of a jacket filled with oil or water. In this country Redwood's viscometer is the standard instrument.

This apparatus consists of an inner cylinder of silvered copper, about 1⅞ ins. diameter and 3½ ins. deep, the slightly concaved metal bottom of which contains an agate jet, with a passage drilled through, 12 mm. long and nearly 1.7 mm. diameter. The orifice is closed by means of a brass ball valve fixed to a wire which fits into the hemispherical cavity of the agate jet. This inner cylinder, which holds the oil to be tested, is enclosed in a brazed copper vessel, furnished with a tap and a heating tube projecting at an angle of 45° to the side and close to the bottom; this outer vessel contains oil or water,

by means of which the temperature of the inner vessel is maintained, and is furnished with a stirring apparatus, consisting of four metal vanes fixed to a copper tube which revolves round the inner cylinder. A thermometer is fixed to the stirring apparatus, and a second thermometer is fixed, by means of a spring clip, in the inner cylinder. A small pointer or stud fixed on the side of the inner cylinder marks the initial height at which the oil should stand when testing. When the temperature is reached at which it is desired to ascertain the viscosity, 50 c.c. are allowed to run into a graduated flask, by raising the ball-valve, and the time occupied noted in seconds by means of a stop-watch.

FATTY AND MINERAL OILS.

Of oils alone we have two great classes—fatty oils and mineral oils. Fatty oils are derived from a variety of animal and vegetable substances. The mention of these at once suggests the obvious division into animal and vegetable oils—a distinction which is based not only on difference of origin, but a difference in chemical constitution, sufficient in most cases for absolute distinction. All these oils have one property in common—when treated with an alkali, a suitable acid, or with certain natural ferments, they will take up the elements of water and split up into a fatty acid or mixture of fatty acids and glycerine. As this change is usually carried out by means of alkali with which the acids combine to form a soap, the change, properly called hydrolysis, is commonly called saponification, and such oils are said to be saponifiable.

A definite amount of alkali is required which varies within certain limits, according to the nature of the oil and within much narrower limits in the case of different specimens of the same kind of oil. This being the case, it is to chemists a useful and easily obtainable figure on which to base an opinion as to (1) the nature of a saponifiable oil, or (2) its freedom from other, especially unsaponifiable, oils, or (3) the approximate amount of fatty oil present in a mixture. This splitting up of a saponifiable oil into its constituents by hydrolysis or saponification, which is very similar to the decomposition of a salt into acid and base, forms the great distinction between fatty and mineral oils.

Mineral oils are, except for their oiliness, of an entirely different character from fatty oils. They are of relatively recent introduction, and may be grouped into two principal classes according to their source—i. e., shale oils obtained by artificial distillation of certain carbonaceous minerals, and rock oils, obtained by boring and then tapping natural "wells" or reservoirs of mineral oil.

In either case the product consists only of carbon and hydrogen, whereas fatty oils also contain oxygen; hence mineral oils are called hydrocarbon oils, and, from their origin, petroleum—stone or rock oil—and unsaponifiable oils, because they cannot be saponified but are unaltered by acids and alkalies. Crude petroleum is a very complex product; it contains an enormous number of chemical individuals of varying properties which are by distillation separated into groups such as the following:

0.665-0.67—Petroleum ether.
0.68-0.72—Petroleum benzine, motor spirit.
0.72-0.78—Ligroin.
0.78-0.82—Burning oil.

Residue in retort—lubricants, vaseline, solid paraffin.

Shale oil, originally discovered by Young, and by him distilled from the mineral known as Torbane Hill mineral, is still largely distilled in Scotland; rock petroleum is found in the Crimea Caucasus (Baku), Galicia, various parts of North America, Rangoon and other places. The largest amount imported to this country comes from America. The portions of petroleum which interest us most in connection with lubricating oils are those heavier fractions, the specific gravity of which is about 0.9 compared with water as 1.0, and which are of a more or less highly viscous nature. The lighter oils are such very mobile fluids, their surface tension and viscosity both being low, that they would allow rubbing surfaces to come into intimate contact, and "cutting" or abrasion would occur to a very great extent.

One drawback to the use of fatty oils, apart from questions of expense, etc., is their tendency to become acid—that is, a portion of the neutral fat splits up into, probably, a diglyceride and free fatty acid—a sort of preliminary or partial saponification under the influence of ferments (enzymes) natural to the oil of certain natural impurities or of air; the action is rather obscure. Be this as it may, the effect is certain; very few oils are absolutely neutral, some are very decidedly acid. Such are likely to attack the metal of bearings and of lamps to greater or less extent, but sufficiently to render more than a very few per cent of free fatty acid in all

cases an absolute disqualification for lubricating or burning oils.

Speaking generally, carefully-prepared animal oils are less liable to become unduly acid than vegetable oils, probably owing to either the absence of acid-forming enzymes in the animal fats or the effect of heat used in rendering the oil on any enzymes which may be present.

Animal oils vary within less wide limits in general chemical properties than vegetable oils. They are for the most part mixtures of only three glycerides, tristearine and tripalmitin and triolein, and hence, although differing in consistency, do not exhibit very great differences as lubricants; for example, no animal oils or fats "dry" in the manner which characterizes linseed and other vegetable oils —they are, in fact, very little liable to "gumming" or similar chemical alteration, and may be considered to more closely approach a state of chemical equilibrium.

MINERAL OILS.

Of recent years the large group of oils known as "mineral oils"—that is, the heavier portions of natural petroleum or of the product of distillation of shale—have found enormous application as lubricants. Their freedom from acidity, when properly prepared, their absolutely inert character in relation to chemical action on the bearing, and also the fact that they are obtained in large quantities as by-products of a great and well-financed industry, have tended to make them very popular lubricating materials.

Some petroleum oils are sufficiently viscous for use in the natural state without further purification other than sedimentation and filtration. Very little such oil is now produced. Petroleum oil, rich in lubricating constituents but too fluid for use without removal of the lighter constituents, is prepared by distillation in vacuo or with a current of steam, so that in either case a high temperature which would cause "cracking" or destructive distillation, thereby increasing the proportion of burning oil, may be avoided. Cylinder oils of good quality are obtained in this way. Filtration through animal charcoal is a means of further purifying and clearing the oil. This process of preparation is called reduction, and the oils thus obtained are called reduced oils—reduced in volume and fluidity from the original oil.

Distilled oils are obtained from "residuum," the residue remaining in the retorts after the distillation of petroleum for burn[illegible] *residuum is drawn from the st*[illegible] particles of coke formed by overheating of the still locally and consequent "cracking" of the oil, and then distilled in vacuo or in steam; by this means a high-flash burning oil is first obtained and then the lubricating oil comes over. This is collected in separate fractions or the whole is allowed to mix. The residue in the retort is mostly carbon, which is used for electric light carbons. The lubricating oil is mixed with paraffin wax, and after purification with acid and then alkali, to remove various objectionable constituents, is reduced to a very low temperature to cause the separation of the wax. The fluid oil is squeezed from this by hydraulic pressure and re-distilled, various portions from spindle oil to (sometimes) cylinder oil being collected. It is not usual to make such heavy oils as cylinder oil in this way.

These oils are usually classed as light and heavy machinery oil, low temperature cylinder oil and high temperature cylinder oil, etc. The colors vary from a fluorescent yellowish-brown to a black or green, and the consistency from that of a rather viscous liquid to a substance thicker than treacle.

CHOICE OF LUBRICANTS.

It will be seen that the engineer has a fairly wide range of substances from which to choose; fortunately so, for his requirements are very varied. All sorts of bearings, from the lightest pivot of a watch to the propeller shaft of a liner, need lubrication to keep them in motion without undue wear or overheating; for this is the way in which the internal work (lost work) of a machine manifests itself. The choice of a suitable lubricant for any one purpose is not always an easy matter. The conditions inside a high-pressure cylinder, for example, are very different from those on a dry shaft (i. e., not wet with steam), or those again from the sliding friction of a piston-rod slide. The cylinder of a gas-engine full of white-hot gas requires a different type of oil again. These varied conditions are met not only by the use of different types of oil but by the admixture of oils. Mineral oils with more or less fatty oil, preferably animal, are used, the animal oil being added to increase both viscosity and "oiliness" at higher temperatures, for mineral oils fall off rather more rapidly in these respects on heating than fatty oils. It is a matter for regret in some ways that this addition should be necessary, for, especially in the case of cylinder oils, the presence of the [illegible] saponifiable oil introduces the possi[illegible] formation of free fatty acid, which

attack metal, and forms a soap, thus re- g lubrication, and by the erosion roughen rubbing surfaces, this, too, in a place is not easily accessible. When the oils are of good quality, however, the danger t so great.

e use of greases made of oils or fats with zinc or other soaps is another means of ning lubrication of surfaces which are cted to great pressure. Opinions differ much as to the advisability of this. The us tests which have been mentioned fur- a good guide, in that they will indicate resence of known objectionable constitu- and give some criterion as to the probable rior of an oil in use. The viscosity, for ple, if taken at various temperatures will some guide as to the consistency of an : those temperatures. There is, however, tunately no very simple means of deter- g the "oiliness" or real lubricating power oil. Various machines have been de- in which by means of friction brakes or mometers the lubricating powers of oils r conditions more or less closely simulat- hose of actual use may be determined, although useful results may be obtained me cases, the conditions in the case of r machinery are very difficult to imitate, y rate in any ordinary laboratory.

The following are for the present the lines on which the engineer and analytical chemist can co-operate with results useful and instructive to both. Knowing the general requirements of the case—i. e., velocity, pressure, etc.—some samples of probably suitable oils could be examined, and those which appeared unobjectionable and were of suitable viscosity tried experimentally on the machinery. That which in the opinion of the engineer was most suitable could then be adopted as a standard which should be "matched" by supplies for use on the machinery. This plan is not, perhaps, simple or very cheap, but a few guineas spent on analyses would be preferable to the damaging of valuable machinery by unsuitable oil.

It is difficult for the chemist fully to understand engineering requirements, especially if he is not on the spot; it is very difficult to make representative small scale tests, and in respect of actual tests on the machinery one can see that the engineer is very much in the hands of his subordinates, who are not in all cases capable of making a good practical experiment in a really economical manner and are not always so entirely free from prejudice, conscious or unconscious, as is desirable in those who are to undertake what is really a judicial investigation.

HARDENED STEELS*

By PERCY LONGMUIR

e ultimate test of a hardened steel is its ing life as a tool, and while it may not ifficult to obtain the requisite hardness, difficult to obtain it with freedom from ing or cracking, from brittleness or rot- ss, and from warping. The hardness alone is therefore insufficient, and the ecognition of this fact in the literature rdening is to be regretted. This is not, ver, the only omission, and, generally ing, the literature of hardening bears little relation to the practice of harden- As a result, practical men view with ist researches on hardening, especially founded on results deduced from micro- al examination. So much is this the case that the microscope is regarded by many competent workers as having hopelessly failed to be of service in the case of hardened steel. As a matter of fact no metallographical investigation yet published has been of the least service as a guide to the thermal treatment of high-speed steels, and with few exceptions comparatively little information of value has been given on the hardening or tempering of carbon steels. These statements do not necessarily imply the condemnation of the microscope as a practical aid in the study of hardening, but rather emphasize the difficulties of interpretation, and also the fact that many scientific workers are unfamiliar with the practical aspects of work. This divergence between practice and theory has naturally led to controversy but ignoring controversial ques-

m a paper read at the Vienna meeting of the Iron eel Institute.

tions as far as possible, an effort is made in the following paper to indicate briefly some variables in the case of carbon steels.

HARDENING PRACTICE.

The suitability of a quenched steel is a function of the carbon present, and so firmly is this recognized in practice that special care is always exercised to obtain the exact percentage which experience has indicated as being desirable. The usual range is from 0.5 to 1.5% of carbon, but in special cases the latter figure is exceeded. The first essential, that of a suitable percentage of carbon, is most rigidly adhered to. Other features calling for note are as follows:

(1) The majority of articles for subsequent hardening are worked into shape from rod, string, or strip, which in turn has undergone a considerable amount of work in reduction from the ingot. Only in exceptional cases are cast materials submitted to hardening. (2) While heating temperatures may reach 1,000° C., quenching temperatures never attain this point, and the usual practice is to quench at as low a heat as is consistent with the properties desired in the tool. (3) Quenching baths, when of plain water, are usually aired, but never fall below the atmospheric temperature. (4) After water hardening the majority of tools are tempered.

In well-organized works the processes of hardening and tempering are operated by specially trained workers, who achieve results of remarkable regularity. The practice of hardening is in a more advanced state than is realized by many scientific workers. As an example, a skilled hardener will harden and temper seven gross of high quality pocket-knife blades per day of nine hours. The tang of the blade is not hardened, but the full length of the blade must be hard. In spite of the rapidity of work, wasters due to faulty hardening are practically nil. Further, blades of like kind hardened by one man are, on microscopical examination, found to give regular structures which do not vary in different sections of one blade, nor yet do they appreciably vary from blade to blade. Similar conditions hold in the general cutlery and tool trades. Hardening operations are remarkably effective and, notwithstanding large outputs, very free from waste.

Several works personally known to the author, engaged on most intricate hardening of a non-repeat character, have losses falling well below 1%. In view of the variety of work handled, of every possible contour, and ranging in weight from less than an ounce up to 300 lbs., the results obtained bear good testimony to the skill of the hardening personnel.

However, notwithstanding the success achieved in hardening practice, there is still room for improvement, and when occasionally erratic results occur the natural object is to endeavor to ascertain the cause with a view to avoiding it in the future. Under these conditions practice, of necessity, has to rely on its own empirical experience.

THE STRUCTURES OF COMMERCIALLY HARDENED STEELS.

A large number of tools, giving a range of from 0.5 to 2.0% carbon, hardened in the ordinary commercial way, and proved by actual trial to be efficient for their respective purposes, have been examined. Irrespective of the source of the tool, the structures were, carbon for carbon and temper for temper, practically identical. According to the amount of carbon present the constituents were ferrite and hardenite, hardenite, or hardenite and cementite. The particular arrangement of structures varied according to the extent of the tempering given. Constituents other than those noted have not been met with, and not a single structure in the whole series could be described as showing a sharply defined pattern.

A second series of steels, purposely or accidentally spoiled in hardening, were procured and microscopically examined. The resulting structures were very erratic, and an infinite number of patterns were noted, giving in many fields characteristic martensitic, austenitic, or troostitic appearances. The majority of the steels were flint hard, but were useless either for cutting or resisting abrasion. Comparing the results obtained, from the two series it may be stated that the characteristic feature of a correctly hardened steel is an absence of definite or pronounced structure, whereas the leading trait of a spoiled steel is the presence of a definitely sharp structure.

The foregoing studies, representing works conditions, were supplemented by a series of experiments conducted under purely laboratory conditions, the object in this case being to examine the influence of varying quenching temperature on the structure of a series of steels of varying carbon content.

The ideal structure (or lack of structure) is produced only in a certain range of quenching temperature, which varies according to the

composition of the steel and the contour of the piece to be hardened. Temperatures outside this range result in more or less crystalline patterns, which in the smallest of sections vary from field to field. Although certain of these patterns may give the appearance of special constituents, they are in reality the product of an abnormal quenching temperature, and steels containing them, although hard, are useless for cutting or resisting abrasion.

The discrepancies in the literature of hardening are due to the fact that certain essential practical features have not met with recognition. Thus any hardened steel, previous to hardening, must have had a considerable amount of mechanical work put on it. Any mechanical stresses present must be relieved by annealing. If the properties of a hardened tool depended solely on the production of a certain type of structure, then cast tools would answer. Experience shows that the fullest properties are only reached on material which has been worked and annealed. Recognition of these features, and a study of advanced hardening practice, would result in the removal of many discrepancies and tend to elevate metallography into a science from which practical men could draw inspiration in times of difficulty.

MASONRY DAMS

By THOMAS G. BOCKING

FROM "THE ENGINEER," LONDON

The design of masonry dams is a subject which has provided material for exhaustive notes and calculations, and is always of interest, although perhaps more often academical than constructional. In a study of the large masonry dams of the world, one is struck with the diversity of design—the variation in profile and proportion. The fundamental problem must, however, be the same in all cases, varied only by the incidental circumstances of site and construction.

This fundamental problem is to provide a mass of material to hold up a certain head of water. As the pressure at the top of the water is nil, and the pressure at the bottom is a maximum, it would seem naturally to follow that the ideal section is such, considering for the moment only the fundamental problem, that the top has no width and the bottom has a maximum width, i. e., a triangle.

Outside and round about this "nucleus triangle," as it may be termed, the individual fears and fancies of the engineer may disport, but they must not allow him to trespass within its lines.

There is very little disagreement in the opinion that the resultant of all forces acting in and about the dam should fall within the middle third of any horizontal line of the cross section. Granting this, the first question that arises is, with what material is the dam to be constructed, and what is its weight? This may range from the brick work in small structures to Cyclopean masonry in huge works, with specific gravities varying from, say, 1.75 to very nearly 3. The section must therefore be adapted to the weight of the material to be placed in resistance against the head of water.

The resultant of all forces is presumed to act at the center of gravity of the structure. If we assume, in the first place, that the dam is of triangular section, the center of gravity is at $2/3$ down, on a level also with the center of gravity of the pressure diagram of the water to be retained.

Let $W = 62\frac{1}{2}$ lbs., weight of a cubic foot of water specific gravity 1.
H = head of water in feet.
M = specific gravity of the masonry.
B = base of dam.

The horizontal component of the triangle of force is $W H^2 \div 2$; which will at once be recognized as a familiar formula for the horizontal pressure of a liquid.

The vertical component is $H W B M \div 2$. That is to say, the weight of the triangle with a vertical H and a base B. $W M$ simply expresses the weight of a cubic foot of the material.

For the resultant to fall at a point two-thirds of the base measured from the water face—the extreme of the accepted limit of

safety—this triangle of forces must be proportional to the triangle of the section of the dam. As B : H : : $WH^2/2$: H B W M/2; or B = H ÷ √M.

This formula will always express the base of the triangular section of walling filling the above conditions:—

$$\text{BASE} = H \div \sqrt{M}.$$

This simple rule provides us with a ready means of ascertaining the nucleus of the structure, and the individual ideas of the engineer are then quite at liberty.

The rule is calculated, assuming a vertical face to the dam. If the face is built with a batter, a vertical line should be drawn from the face of the wall at the top and the calculated base set back from that line, allowing additional base due to the batter. This keeps us within safety, as, with the extra weight in the wall to the same head, the resultant falls within the middle third instead of at the ⅔ point.

As no attempt is made to store water until the reservoir is practically free from silt, the specific gravity of the impounded water may be taken as 1, but it must always be remembered that silt-laden water exercises a much heavier pressure, and if such circumstances are likely, due allowance must be made. In a paper read by Mr. David Gravell, M. Inst. C. E., before the Society of Civil and Mechanical Engineers, and reported in the "Engineer" of March 11th, 1887, the opinion is expressed that in some districts, in time of flood, the weight of water is increased to 75 lbs. per cu. ft., or an increase of 20%.

It must be urged in conclusion, that the suggested formula is not given to supersede the usual calculations, but only as a check thereon. Great problems of this nature, involving so many considerations, cannot be dealt with in a few moments; but the minimum structure can be very quickly found, which must, under no circumstances, be reduced.

[Sections and data of five large masonry dams are given (Assûan, Burraga, Dhukwa, Vyrnwy and Wachusett), from which the author finds that the nucleus triangles are well within the actual structures.—Ed. T. L.]

THE NATURE OF TRUE BOILER EFFICIENCY

By W. T. RAY and HENRY KREISINGER

FROM "THE IRON AGE"

The Steam Engineering Division of the United States Geological Survey, in conducting boiler tests for the purpose of determining the heat values of coal for steaming purposes, found early in its experiments that the results obtained would have but little meaning unless the boiler performance were subtracted or divided out so as to get the efficiency of the grate and furnace. The purpose of this article, which is largely an abstract from a bulletin prepared by the above named division, is to offer a few formulated laws governing the rate of heat absorption by boilers and to present the more important results of these experiments.

HEAT TRANSMISSION

Heat travels from any hot body only to bodies at lower temperatures; therefore any boiler can absorb only that heat which is above the temperature of the water in it; heat below this temperature will not flow into the boiler water and therefore is not available for absorption. Commercial boilers absorb only part of the heat which is available for them; the percentage of the available heat which is absorbed by the boiler is called the true boiler efficiency. This efficiency depends somewhat on the way the heat is presented to the boiler, but chiefly on the construction of the latter. The true boiler efficiency is then defined as the ratio of the heat absorbed by the boiler to the heat which is available for it, counting only the heat available which is above the temperature of the boiler water.

In any steam generating apparatus the heat is evolved by the burning of fuel in the furnace and is then transmitted through the

* [illegible]

space and through the water heating plates into the boiler water.

In practice, the water heating plate of the boiler is always, to some extent, covered on the outside with a coating of soot, and on the inside with a layer of scale or mud. Just on the outside and entangled in the small recesses of the soot coating, is a dense film of gas which adheres to the solid. The density of this gaseous film decreases outward from the solid layer of soot. It is somewhere within this gaseous film where the dry surface of the water heating plate can reasonably be assumed to exist. There is a similar film of steam and water, adhering to the layer of scale on the inside of the boiler, which film can be considered to contain the wet surface of the heating plate.

Heat is communicated to the dry surface of the water heating plate mainly in two ways:

1. By radiation from the hot fuel bed and furnace walls.

2. By convection from the moving gaseous products of combustion. By convection is meant here the process of displacing cold molecules from the adhering film of gas by hotter ones from the moving mass of hot gases.

From the dry surface of the heating plate, the heat is transmitted through the layers of gas, soot, metal, scale, and steam to the wet surface purely by conduction. From the wet surface the heat is carried into the body of the boiler water mostly by the convection of the circulating water. The retardation of any one of these three modes of heat travel lowers the efficiency of the boiler.

It has been said that the dry surface of the water heating plate may be considered as being somewhere in the adhering film of gas. This statement is more correct when it refers to the heat communicated by convection than to the heat imparted by radiation. In the latter case the greater part of the heat passes through the gas film directly to the soot, because gases are to a great extent permeable to the radiant energy.

As the adhering films of gas and the film of steam and water may be, and very likely are, of considerable thickness, the heat must pass through part of the thickness of the film by conduction, and as both the gas and steam are very poor conductors of heat, the resistance which these films offer to the passage of heat may be even greater than the combined resistance of the soot, metal and scale.

RATE OF HEAT RADIATION AND CONDUCTION.

Although this paper is intended to discuss mainly the factors which influence the rate of heat impartation by convection, a brief explanation of the laws of the rate of heat radiation and the rate of heat conduction will help in making clear the whole matter of heat absorption by the boiler.

The quantity of heat which the boiler receives by radiation from any hot portion of the furnace or the fuel bed may be taken to be proportional to the difference of the fourth powers of the absolute temperatures of the hot parts of the furnace and the soot coating on the boiler plate. This law of radiation is known as Stefan & Boltzmann's law. Strictly speaking it applies only to black bodies; however, within the usual temperature range of the boiler furnace it can be applied to boiler problems without any serious error. It shows that the quantity of heat received by the boiler by radiation increases very rapidly as the temperature of the furnace rises. In boilers where the heat received by radiation is a predominant part of the total heat absorbed, the true boiler efficiency necessarily increases with the rise of the furnace temperature.

The quantity of heat which can be transmitted through a given unit of water-heating plate in a unit of time depends on the difference of the temperatures of the dry and the wet surfaces of the heating plate, and the conductivities of the substance between the two surfaces. For instance, if it is required to transmit double the quantity of heat in the same length of time, the difference of the temperatures of the two surfaces must be doubled. Since the temperature of the wet surface is nearly the same as that of the steam in the boiler and therefore can not be lowered, the temperature of the dry surface must be raised; as it is, this dry surface of the heating plate which cools the furnace gases, the rise of its temperature results in the rise of the temperature of the escaping gases. Thus we see that with the same conditions of the heating plate and the same initial temperature of the furnace gases, the temperature of the escaping gases will rise with increasing capacity, thereby decreasing the efficiency of the boiler in corresponding degree.

SURFACES OF HEATING PLATES SHOULD BE KEPT CLEAN.

The main cause of unnecessarily great differences between the temperatures of the dry

and wet side of the plate and the consequent high temperature of the waste gases is the presence of soot and scale on the surface of the heating plate. The heat conductivity of both of these substances is very low, which fact emphasizes the importance of keeping the surfaces as free from such deposits as possible.

The heat imparted to the boiler by convection forms in most cases a large percentage of the total heat received. It is therefore very desirable, for the sake of better boiler construction and operation, that the factors which influence the rate of heat impartation by convection be more thoroughly known. Excepting a few experiments done abroad and bearing only indirectly on the steam boiler problem, nothing has been done toward determining these factors. The Steam Engineering Division of the United States Geological Survey recently started the investigation of this problem, as an incidental feature in its regular work in testing the quality of coals for steaming purposes. These investigations consist of laboratory experiments made on small models of horizontal multitubular boilers. The laboratory methods and the small boilers were taken up because, first, it requires small outlay of money to conduct the experiments, and second, it is easier on a small laboratory apparatus to control all the conditions than it would be the case with a large boiler and furnace; it is necessary in work of this kind to keep all the conditions constant.

RESULTS OF THE GEOLOGICAL SURVEY'S TESTS.

In the experiments thus made small multitubular boilers were used because of their simple form, and heat was generated by a miniature electric furnace in order to avoid the deposit of soot on heating surfaces. As the result of a large number of careful tests, one of the most important observations made was that the heat absorbed by the boiler per second varies almost directly as the calculated initial velocity of air. With the same initial velocity of air tests with higher temperatures show a higher rate of heat absorption [illegible] as the [illegible] temperature [illegible] [illegible] rate of heat absorption does not [illegible] [illegible] [illegible] gas tempera-ture has been reached there is little or no gain in the heat absorbed by further rise in temperature. This fact indicates that the rate of absorption is influenced by another factor, which varies inversely as the temperature; this factor is the density of the gas.

It was also demonstrated from tests conducted that true boiler efficiency drops at first very rapidly when the difference of drafts increases; but when the latter reaches a certain value, which varies with size of tubes and degree of temperature, the efficiency remains nearly constant. The small gradual drop noted in the efficiency beyond the point where the latter remains nearly constant may be accounted for by rapidly increasing capacity.

It was also noticed that a given difference of drafts pulled practically the same amount of air through two boilers in which the tubes, of same diameter, in the one were nearly twice the length of those in the other. This would seem to indicate that most of the resistance is at the entrance of the flues and very little of it in the tubes themselves, so that increase in the length of the flues increases the total resistance but slightly. Nevertheless, adding to the length of the flues does not, when carried beyond a certain limit, materially increase the true boiler efficiency, for it was shown in a test that by doubling the length of flues a gain of only 8% in true efficiency was made. Further tests yielded results that would indicate the superior true boiler efficiency of the smaller diameter flues over those of the larger diameter.

DEDUCTIONS.

The deductions drawn from these experiments, briefly summarized, indicate that:

a. After the velocity of gas parallel to the heating surface has reached a certain value the rate of heat absorption is almost proportional to the velocity.

b. The rate of heat absorption increases when the initial temperature rises; it also seems to vary directly with the density of the gas.

c. Increasing the diameter of flues decreases the efficiency of their absorbent power; increasing the length of flues beyond a certain limit increases their efficiency very little.

d. Most of the resistance to the passage of [illegible] the flues is at the entrance into the tubes [illegible] length of the flues increases the [illegible]

COMPLETED PORTION OF THE WEST NEEBISH CHANNEL, SHOWING THE DRY STONE WALLS LINING THE SIDES ABOVE THE SURFACE OF THE ROCK.

FACILITATING NAVIGATION ON THE GREAT LAKES

CONDENSED FROM "ENGINEERING NEWS"

An important piece of work now being carried out to facilitate navigation on the Great Lakes is the improvement of the St. Mary's River by the construction of the West Neebish Channel at what are known as the West Neebish Rapids, 17 miles below Sault Ste. Marie, Michigan. These rapids, as their name implies, were situated in the river channel on the west side of Neebish Island, and in their natural state extended a distance of half a mile over an exceedingly shallow watercourse, with a maximum depth of about 3 ft. and a width of a quarter of a mile. The rock dike of Niagara limestone forming this barrier between Neebish Island and the mainland, is about 2½ miles in width, from deep water to deep water. This dike, which constitutes the bed of the rapids, is one of the two low points in the ridge, whose higher parts form Sugar and Neebish Islands. The other low point is the Middle Neebish Channel on the north side of Neebish Island, and between it and the southern extremity of Sugar Island. This is the channel now used by all the traffic between Lake Superior and the other great lakes. It was excavated for the U. S. Government by contract, by the method of submarine blasting and dredging, and required five years to complete.

The work on the new West Neebish Channel was commenced in May, 1904, and is expected to be completed by December, 1907. It includes two different methods of construction: (1) Excavation under water; (2) excavation in the dry, the original channel having been closed by cofferdams and then

pumped out. A view of this channel is shown herewith. The contract requires the excavation of a clear channel width of 300 ft. for a distance of 13,300 ft. Of this distance, 8,560 ft. is called rock excavation, in which there are 1,700,000 cu. yds. to be removed; and the balance is 287,000 cu. yds. of earth. There is considerable stripping of earth and boulders (river drift) in the rock section, and a good deal of rock projecting above the 22-ft. plane in the earth section. In the dry section this stripping has run from scraping to 15 ft. in some places, and the earth is estimated at 12% of the rock excavation. The depth of the rock varies from nothing at either end to 27 ft. near the middle.

WIRELESS TELEGRAPHY*

By WILLIAM MAVER, JR.

Wireless telegraphy now appears to be settling down on a practical basis. It is finding its important field to be where all those who have not been actuated by interested motives have consistently stated it would be found—namely, as a means of communication between ships at sea and between ships and the shore. How long it will hold this field undisputedly depends upon the measure of success that may attend the efforts of those who are now endeavoring to perfect wireless telephony. At least half a dozen inventors are at work on this problem in this country and Europe, and it is reported that the wireless transmission of speech has been experimentally successful up to distances of several miles overland; but apparently much remains yet to be done before wireless telephony, even for short distances, becomes an accomplished fact. Should this hoped-for result be achieved, however, it is evident that for many purposes it will displace wireless telegraphy. For example, probably one of the chief reasons why wireless telegraphy is not already universally installed on all manner of sailing vessels and steamships is the necessity for employing an expert Morse operator to transmit and receive messages. Wireless telephony, even if only available for a comparatively short distance, obviously could be installed to advantage in the officer's room of every ship that floats the ocean, lake, river or harbor, and perhaps on railway trains as well, for any purpose that might arise.

Wireless telephony is not yet here however, while fortunately for those that go down to the sea in ships wireless telegraphy is here, and it is already installed or is being installed on every lighthouse and on the vessels of every important navy and steamship line in the world. It is probably easily within bounds of accuracy to say that there are now over 2,000 wireless stations, including ship and shore stations, in operation in various parts of the world, and this number is being added to daily.

The distances covered by wireless telegraphy in regular operation may be set at from one mile to fifty or 100 miles. When the statement is made, as it frequently has been, that messages have been received from ocean-going vessels several days out from New York, it may be taken for granted that these messages have been received at one or other of the Atlantic coast stations within wireless signaling distance of the vessel, and by those stations repeated by overland wire telegraphy to New York. There is no doubt that messages are received under favorable conditions at distances of several hundred miles away from shore, but these are exceptional cases. No regular interchange of business is at present carried on at those distances.

While we frequently run across the statements of interested brokers in wireless-telegraph stock that transatlantic wireless telegraphy will shortly be accomplished, it is noticeable that Marconi, Fessenden and De Forest have of late been silent on this subject. Fessenden indeed has, with commendable frankness, practically admitted that the difficulties of transatlantic wireless telegraphy are at present well-nigh insurmountable. His experiments were continued for nearly one year between Massachusetts and Scotland. He found that there are at least two serious obstacles in the way of transatlantic wireless sig-

*[illegible]

naling. First, atmospheric absorption of the electric-wave energy of the signals. Up to distances of 1,000 miles this absorption is not very marked, but beyond this point it becomes very important. The other difficulty consists in the inability to maintain syntony, or tuning of the apparatus, at the respective transmitting and receiving stations. The difficulty, in the words of Mr. Fessenden, "is in getting the stations which are to communicate to maintain their frequencies sufficiently regularly." It was found impossible to receive messages when the frequency varied one part in 1,000,-000. This, it may be noted, is equivalent to saying that if a telegraph system which depended for its successful operation upon the synchronism of wheels at the sending and receiving stations should vary one part in 1,000,-000 the system would not operate. While Mr. Fessenden is hopeful that these difficulties will be overcome, the prospect for an immediate realization of this hope is not very encouraging. But fortunately, again, there is no real necessity for transatlantic wireless telegraphy, or cableless telegraphy, as some wireless experts take pleasure in terming it. The Atlantic cables are still doing business at the old stand, and there is every reason to believe that they will continue to do so for many years. Singular as it may seem to some people there is, apart from occasional injury to the cables, no method of telegraphing that is as reliable as submarine-cable telegraphy. The reasons for this are obvious. The cable, year in and year out, works undisturbed by changes in weather conditions. Lightning storms do not affect its operation, and vagrant currents from neighboring and unneighborly electric traction circuits, or induction from high-tension alternating-current systems, can never approach within harmful distance of its sensitive apparatus. Similar immunity from these disturbing factors in overland telegraphy would, there is no doubt, be gladly welcomed by the members of this association.

Apart from the filings coherer it may be said that the most prominent type of detectors now in use are the magnetic detector employed by the Marconi interests, the carborundum detector employed by the De Forest company and the various electrolytic detectors of the Fessenden and Shoemaker types. The magnetic detector, the carborundum detector and the electrolytic detector require a telephone receiver for the reception of signals. The magnetic detector was described in the author's paper on "Improvements in Wireless Telegraphy," read before the Indianapolis convention of this association. The carborundum detector consists of a crystal of carborundum which is clamped between two metal electrodes. Otherwise, so far as the arrangement of circuits is concerned, it simply displaces the filings coherer, but does not operate a relay. The electrolytic detector consists of a small cup containing a dilute solution of nitric acid, into which the terminal of a very fine platinum wire is placed. Another wire enters the acid from the bottom of the cup. When current from a small dry battery is passed through the solution by means of the fine wire, polarization takes place and current ceases to flow in the circuit. Incoming electric waves appear to dissipate this polarization, causing variations in the current of the local circuit, and sounds corresponding to dots and dashes are heard in the telephone receiver.

The De Forest "audion" is also one of the more recently invented wireless detectors. This detector, briefly described, consists of an incandescent filament in a vacuum, shunted by a local circuit in which a battery and a telephone receiver. Incoming electric oscillations appear to affect the electrical condition or equilibrium of this circuit and set up variations of current therein which are heard as dots and dashes in the telephone receiver. This receiver was fully described in the transactions of the American Institute of Electrical Engineers for 1906.

Another detector which promises to be of utility in practical wireless telegraphy is the silicon detector, the invention of G. W. Pickard. This detector is of the thermoelectric type of wireless receivers. It produces its own electromotive force. Its electrodes are pure silicon and a metallic element of low resistance. The energy ofg the incoming electric oscillations are converted into joulean heat (C^2R) at the element having high resistance (the silicon), which heat is converted at the contact point into a short pulse of direct current in the telephone receiver; and a long or short continuation of these pulses produces a dash or dot in the receiver. Mr. Pickard states that a fragment of silicon merely held with suitable pressure between two flat-ended brass rods gives excellent commercial results. This detector has the advantage that no battery is required in the local circuit. In sensitiveness it compares favorably with the electrolytic and magnetic detectors, according to tests made by

Mr. Pickard. The carborundum detector is about one-half as sensitive as the last-named detectors.

It is interesting to note that the telephone receiver has been found to respond to a single impulse of current of very much less strength than is required to energize the most sensitive wireless detector, and were it not for the high inductance of the telephone receiver, the intermediate wireless detector would not be necessary. At the high frequencies used in wireless telegraphy, however, namery, of the order of 500,000 or 1,000,000 per second, the inductance of the telephone receiver renders it mute.

An improvement in wireless telegraphy that may lead to important results consists in the use of undamped oscillations, with which numerous experiments are now being made by Poulsen, Shoemaker, the Telefunken company and others.

In the ordinary "spark" gap transmitter, it is known that between each spark or train of sparks there is a rapid falling off or damping of the amplitude of oscillations; consequently the full benefits of resonance in the tuned receiving circuits are not obtainable. Poulsen's method of obtaining undamped oscillations is an amplification of the Duddell "singing arc" and consists in employing an electric arc of peculiar construction shunted with a capacity (condenser) and inductance of a wireless transmitting circuit.

In Poulsen's device the positive electrode is copper, the negative electrode is carbon. When the capacity and inductance are suitably adjusted, rapid oscillations of uniform amplitude are established in the circuit and thence are thrown upon the vertical wire. These oscillations are broken into dots and dashes in the usual way. Unfortunately, thus far the energy output by this method is low, and it remains to be ascertained whether or not the advantages of uniform amplitude by conducing to a better utilization of resonance will more than offset the disadvantage of reduced energy output.

Another improvement in the practice of wireless telegraphy consists in the employment of electro-wave meters by means of which the wave-length or the wave frequency may be measured. These wave meters are based primarily on the principle that with an exciting circuit in proximity to a secondary circuit, a maximum current will be induced in the secondary circuit when the two circuits are in resonance, which will be when they possess corresponding inductance and capacity. Knowing the capacity and inductance of the secondary circuit, the frequency and wave-length of the oscillations are deducible. Increased familiarity of the operators with the apparatus has also naturally tended to improve results in the actual operation of the various systems. Apart from the foregoing noted features and certain improvements in the details of apparatus and the arrangement of vertical wires, there has been comparatively little advance made in the art of wireless telegraphy during the past one or two years.

A short description of some experiments conducted recently by the Telefunken Wireless Telegraph Company, of Berlin, relating to the use of wireless telegraphy between railway trains in motion and fixed stations, may be of interest to the members of this association. The experiments were made on sections of railway track about 12.5 miles in length, with four stations about four miles apart within this distance. The wireless outfit of each fixed and moving station consisted of a filings coherer receiver and an induction coil transmitter, together with the other apparatus usually employed therewith. A coach containing the wireless outfit was equipped with a rectangular wire suspended by posts about one foot high at each corner of the roof of the coach. The wire was attached to porcelain insulators on the top of these posts. A single wire was led from this wire to the apparatus within the coach. A ground was obtained through the iron trucks of the coach. The fixed station was between the telegraph poles. The aerial wire was erected horizontally between the poles and paralleled the regular telegraph wires for a distance of 195 feet, about one foot therefrom, and was carefully insulated from those wires. A wire connected this aerial wire to the apparatus in the fixed station. The ground was made by a wire connection to the nearby rails. Current for the induction coil was supplied by eight portable storage cells giving sixteen volts and having an output of about five amperes with a spark-gap of 0.12 inch. The maximum distance of the train from the tracks was [illegible] feet.

By this arrangement reliable signals were sent and received at a distance of 7.5 miles.

NOTES ON ENGINEERING AND APPLIED SCIENCE FROM ALL SOURCES

bestos Shingles.—Shingles are now made r a patented process from asbestos fiber Portland cement. Owing to the enormous ure under which the shingles are manu-red, it is said that they absorb, when , only about 5% of their weight of water; when exposed to the atmosphere for a or two that hydration and subsequent allization convert them into impermeable coverings.

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lalith.—This new German composition d to possess the characteristics of vulcan-rubber and celluloid, excepting that it is ess and not inflammable. The article is factured from skimmed milk, freed from , undergoes a process of vulcanization, which the plastic material is placed under pressure for the purpose of securing de-e forms. From 60 quarts of skimmed about 18 ounces of "Galalith" are pro-l. The pure article is transparent and e colored with the aid of an acid, in imi-of ivory, tortoise shell, vulcanized rub-amber, marble, coral, etc. The composi-n a thoroughly warmed state (by an im-on into water of 212° F.) can be formed will retain its shape. It is further claimed "Galalith" can be worked as natural horn, e way of sawing, cutting, polishing, etc., hat it is not affected by coming in contact oils, grease, ether, benzine, etc. "Gal-" sells at 45 to 90 cents per pound.—John ehl, Stettin, in "Consular and Trade Re-"

Improved Mercury-Vapor Lamp has been tly invented by Dr. Küch, in which the tube of the original Cooper-Hewitt lamp placed by quartz. In the ordinary ury-vapor lamp the power consumption es a minimum at about 0.6 watt per e; if more power is supplied to the lamp, andle-power increases at a slower rate the increase in watts, and the efficiency fore decreases. When the power reaches a maximum, i. e., just before the softening point of the glass, the efficiency is one watt per c.-p. By employing quartz, with its high melting point, instead of glass, the lamp tube can be run up to a much higher temperature, and in doing so Dr. Küch found that, after a maximum consumption, which may be as high as about 1.2 watts per c.-p., the efficiency once more improves, and not only is the former value of 0.6 watts per candle-power again attained, but still better efficiencies as good as $^1/_4$ watt per c.-p. can be arrived at without difficulty. Another advantage of employing quartz is the reductions which are rendered possible in the dimensions of the lamp. While mercury-vapor lamps for 110 volts require glass tubes about 44 ins. long and 1¼ to 1½ ins. in diameter, the lighting tube of the quartz lamp for the same voltage is hardly 3¼ ins. long and 0.4 to 0.6 in. in diameter; for 220 volts it is about 6 ins. long. It is therefore possible to employ fittings resembling those of arc lamps. On switching on the quartz lamp, the light fills the whole tube as in the known patterns of mercury-vapor lamps, but after a time the glowing discharge becomes a mere thread, and the color changes from the objectionable greenish-blue to a yellower or whiter light.

Selection of Electric Motors.—It is sometimes a question as to what type of electric motor is best for a given condition of work. To aid in making such a selection I will give a few short rules for the simpler forms of direct-current machines.

Series-wound motors should be used for heavy loads and variable speed.

Compound-wound motors should be used for heavy starting load and fairly constant speed.

Shunt-wound motors should be used for light starting load and constant speed.

Notes:

A series-wound motor with its high starting torque makes it possible to obtain a rapid acceleration under load, as in railway work.

A compound-wound motor will vary in speed about 10% between no load and full load, slowing down under full load.

A shunt-wound motor will give a nearly constant speed for variations in load as long as the potential of the current supply is constant.

A change of speed may be produced by varying the strength of the magnetic field; the weaker the field the higher the speed.

Motors may be overloaded 25 to 50% for short periods, provided the intervals of rest are sufficiently long to allow for cooling.—C. C. Stutz, in the "American Machinist."

The Ageing of Mild Steel.—At the Vienna meeting of the Iron and Steel Institute, Mr. C. E. Stromeyer contributed a second long series of tests of various classes of steel under varying conditions. (His earlier tests were briefly noticed in this department of the July issue). Some of the samples were nicked and bent at once, others were stored from three to eight months before bending, some were boiled for fifteen minutes, while others were kept in the steam space of a boiler for seventeen weeks under a pressure of 120 lbs.; others, again, were kept in cold storage for the same period at a temperature of 16° F.

As a result of these experiments Mr. Stromeyer claims that the heating of steel for long periods has a distinctly deleterious effect, which shows itself in some cases gradually, in others more rapidly. The frozen samples gave better elongations than the steamed samples, and even than the stored specimens, the mean elongations being 24% (original), 8% (steamed or boiled), and 16% frozen. The long-continued steaming creates brittleness near the point of injury, such as a crack. This may have an important bearing on aging effect, and it with injudicious calking (which grooves the lower plates), may account for some explosions of boilers. Also, single-riveted lap-joints have a tendency to create local bending stresses instead of simple tension. The author concludes that high-pressure hydraulic tests [illegible] applied cause [illegible] bending tests with sheared edges [illegible] planed bend tests [illegible] are best for [illegible] cold bends are no better [illegible] ordinary bend and temper tests and cold bends, as the former two would have detected high-carbon steels.

The experiments have not resulted in the discovery of a test that will differentiate between reliable and treacherous steels; but the author pointed out that steel does possess ageing properties, and that certain practices in use among some engineers have dangerous possibilities.

A New Hydroplane Boat.—In a recent issue of "Engineering," a new hydroplane boat, designed by MM. A. Crocco and O. Ricaldini, in Rome, was described and illustrated. The boat is 26 ft. 3 ins. in length, and is fitted with a Clément-Bayard 80-100 HP. motor, having 7 × 7-in. cylinders. The motor runs at a speed of 1,200 revolutions per minute, and drives two aerial propellers. The boat is provided with hydroplanes only at its stem and stern. The planes at the bow are arranged in the manner of a V, while those aft, though similarly disposed, do not join at the inverted apex. These planes, and the principal members of the frames supporting them, are made of steel plating, the remaining parts of the carrier frames being of aluminum. The propellers are of doubled aluminum plating, and weigh each about about 26 lbs. Their pitch can be altered while running and they can be reversed. Including all machinery, fuel, and two men on board, the vessel weighs 3,300 lbs. When travelling the hydroplanes cause the boat to rise, so that the hull is clear out of the water, and at the speed of 44 miles per hour, which has been obtained with this novel form of vessel, the hull is about 18 ins. out of the water. It is stated by the inventors of this novel type of boat that on commencing a run, when a speed of about 6 miles per hour is attained, the bows begin to lift in the water, and the fore-fins slowly emerge as the speed increases. At a speed of 15½ miles per hour the hull is wholly out of the water, only the flat portion near the stern skimming on the surface. At from 19 to 22 miles the boat is supported solely by the V-shaped planes, and at the highest speeds yet attained the hull is, as stated, 18 ins. out of the water.

[illegible] researches have sufficiently established the position that meteoric irons [illegible] essentials, be properly included [illegible] of steel; the fundamental difference [illegible] that, while artificially produced steels [illegible] iron carbon alloys, meteoric [illegible] iron nickel alloy with meteoric carbon.

BOOK DEPARTMENT

THE LIBRARY AND THE BUSINESS MAN

In a lengthy and detailed paper on the above subject, read before the American Library Association at its annual convention in Asheville, Mr. G. W. Lee aimed to show what library work can mean to business men. men. While it is probably truethat most public libraries are well equipped with statistical and technical literature, their usefulness to the general public as business aids has not been fully recognized. The author bases his paper on the work and needs of the private library of the Stone and Webster engineering corporation, of which he is librarian, and treats the subject under the following divisions:

Scope of the business.
Demands upon the library.
Sources of information.
Working methods, filing systems, etc.
Improvements and limitations.
Some unsolved problems.
Information bureaus.
Esperanto.
Miscellany.

For the purpose of a condensed review of the paper, applying the methods to any business, some of these divisions may be neglected, while the first division becomes an individual matter of each house, on which the formation, character, extent and system of the library must be based.

Under the division of Demands upon the Library, it would be impracticable to give anything like a complete list of the questions and requests that might come up for immediate attention or for extended research. A general classification that might well serve to indicate the scope of information which a private library should have ready access to, would include engineering questions, names and addresses, questions of spelling, rhetoric, etc., statistical questions, costs and general finance, and a multitude of general questions.

How are such questions answered? The greater part of the required information is obtained through the indexes to the technical journals and through published books on engineering subjects. Some call for considerable experience, beside familiarity with a number of reference books. They are such as might arise in any office, viz.: Name of Secretary of State of Texas, Vice-President of some railway, or the address of some engineering society, and are answered principally by reference to almanacs, newspaper directories, "Who's Who," the advertising pages of trade journals, etc.

Questions of usage in English are almost unlimited in range and number, and there is many a failure to find rule or authority for much that one would expect to be settled by ordinary dictionaries or encyclopedias. Statistical questions arise daily in all business offices. The variety of these and their apparent uselessness to the business of the concern and the very fact that they do arise and must be answered, shows the interdependence of all human knowledge and how difficult it is to anticipate the full requirements of a business library.

The subject of costs and finance is, perhaps, the most common factor in business life, and a certain routine of reference books and experience enables one to put the questioner readily in touch with the answers to many questions of this kind, though many others may be puzzlers, as they always have been and as they probably always will be. There are many unexpectedly difficult questions—information that one is assumed to know or readily ascertain as an everyday matter in his calling—which, though apparently easy, will prove almost hopeless to answer. For instance, look for the date of the opening of the first interurban railway.

The Sources of Information may be classed

as follows: Documents, such as records of the business; books, pamphlets and periodicals; maps, atlases, etc.; indexes, catalogues and lists; miscellaneous publications; other libraries, manufacturers and business houses, by means of letter and telephone. One naturally expects that books and periodicals are the chief sources of information in a business library as in any other, but nearly every large concern has a quantity of records stowed away, sometimes easy of access for reference purposes, more often difficult. These documents are always valuable, being records of work planned and accomplished, and are adapted to the particular needs of the business with which they are connected. A book or periodical can generally be replaced or seen elsewhere, but a typewritten document involving a business proposition, statistical or financial information or legal matters such as franchises, petitions, mortgages, agreements, contracts and the like, is often a sole copy and difficult or impossible to replace. There are also reports, estimates and a great variety of engineering or other business papers; besides maps, drawings, tracings, photographs, etc., all of which, if properly filed and indexed for reference,, form a strong foundation on which to build a working library. A wider scope of information is obtained by subscribing for and binding periodicals and buying special books on special subjects—everything is not contained in Webster's or the Century Dictionary or in any one encyclopedia. The range of literature of this kind is, of course, limited only by the range of the business interests of the concern. There are to-day hundreds of trade and class periodicals representing every class of industry, and there are reference books, handbooks, manuals and ordinary books bearing on general subjects and special features of these subjects; there are also government documents, bulletins of all kinds, society transactions and trade house organs without number, so that any concern should have little or no difficulty in making up a useful collection. The difficulty arises in the proper indexing of the material for efficient service.

The various periodicals publish their own annual or semi-annual indexes, but the most important source of information regarding technical periodicals is the classified descriptive "Index to Technical Articles" published monthly in Technical Literature. This is printed on one side of the page only and the items can be clipped and arranged in classified form either on cards or sheets, so as to have ready references as nearly up-to-date as possible. Among indexes to more general literature which are useful in every business library are the Reader's Guide, the Cumulative Book Index, the Book Review Digest, the United States Catalogue, the A. L. A. Booklist and a few others of minor importance. Among miscellaneous publications, the value of some of which are unappreciated, are the Document Catalogue of Government Publications, the Statesman's Year Book, the Almanacs, city directories, telephone books of other cities, all of which are easily available by any person.

So far, only the demands on the library and the resources for meeting them have been considered. The Working Methods—the methods of filing and keeping track of the literature and information are not of less importance than is the matter of obtaining it. The classification system most generally used is the Dewey Decimal System, which may be adapted to any classification of knowledge and carried out to any limit of specialization desired.

In Technical Literature for February an article appeared entitled "The Indexing of Technical Information," in which the subject is treated editorially, and in the same issue are articles on "Engineering Periodicals and the Card Index," by Prof. H. Wade Hibbard, of Sibley College, and "A Mechanical Engineering Index," condensed from a paper read before the American Society of Mechanical Engineers by Professors W. W. Bird and A. L. Smith of the Worcester Polytehnic Institute. The information given in these articles will be found most useful in the formation of Working Methods and the development of these methods must depend on the requirements of the business.

The library, in order to retain its usefulness must keep fair pace with the growth of the business by way of additions and improvements; but at the same time there must be limitations to this growth, or the average library space will become so congested with material as to render it both useless and inconvenient. Not only must space be considered, but also the practical value of the material. It is generally acknowledged that engineering books go out of date very quickly, therefore, if the books are to be of maximum value, it is necessary to keep in touch with new editions and to purchase them as soon as practicable af-

ter publication. In spite of their possible future use, many books, pamphlets and periodicals must be given or thrown away to prevent congestion and to retain the effectiveness of the library; but, on the other hand, this practice of deciding what is essential, of separating the wheat from the chaff, will often prove a means of making the library of livest value to the concern.

The aim is, of course, to keep the files in close touch with what the organization needs or is likely to need, and to meet as far as possible the special interests of individuals. Important questions of the day, new developments in technical lines and specialized subjects must always be considered, besides the accumulation of information for the attention of the concern, regarding accidents, hostile comments regarding their interests, new inventions, work of competitors, etc.

A record should be kept of all information obtained from outside sources for future reference in case similar questions arise.

Some apparently unsolved problems that might be encountered are the keeping in touch with new books and book reviews, the disposal of old books, the securing of back copies of periodicals to complete broken files, and the obtaining of valuable documents that are not printed for extensive circulation and to keep files of back numbers for sale.

As mentioned above, engineering books soon go out of date and are replaced by new and revised editions or are superseded by entirely new books. All of these cannot be bought merely on the advertised statements. Who, then, is to advise if the new book is worth while? What may be most suitable for one man's purpose will be useless for another's. Sometimes books may be had on approval and can be submitted to different persons in the office for inspection, but too often the men whose opinions would be of value are very busy or are absent, and a man of lesser importance is called on to decide. In this way many books hardly worth while may be hastily approved, while others of importance may be as hastily rejected. Book reviews differ widely and often reviewers of equally good standing will express directly opposite opinions as to the value of a given work. This difficulty of judging books is well illustrated in the suggestive article, entitled "The Ideal Book Review," in Technical Literature for April.

The question of the suitable disposal of old books and periodicals has always been as serious as is that of obtaining back copies. Any one library may have many of these to dispose of and is constantly in need of certain copies of other periodicals. But how are they to make the demand and supply meet? There are editions of books which have been superseded, literature obtained for a specific purpose which it has served and which is not likely to be needed again, there are books that must be discarded for want of space—all these are of use to someone, but to whom? Likewise where can the books and periodicals required be obtained? There are several sources for securing odd copies of some periodicals where the publishers do not pretend to keep files of back numbers for sale, but probably the only method of disposing of similar goods is by advertising in the columns of some periodical reaching the class of readers that might want them.

Of what value in dollars and cents is the library to the business organization? It may be contended that it is a non-productive expense, and in the majority of cases it may be an exceedingly heavy expense. It keeps the firm in touch with up-to-date methods and what is going on in the world in their lines of interest, and once in a while a question is answered which enables them to see that thereby plans in their work have been changed to effect the saving of thousands of dollars; for this reason, the reference library is a good thing and ought to be maintained in spite of all objections and apparent expense.

The possibilities of a business reference library are as far reaching as the work is interesting; there is hardly a business concern that has not the foundation of such a library in its offices, and it is merely a matter of the proper classification and up-keep of this to make it an important part of the office equipment. Libraries are becoming more and more recognized as centers of knowledge rather than centers for the storage of books, and their extended use by business houses to co-operate with their own private reference library is a development that is still in its infancy.

THE COLOPHON*

THE ORIGIN AND DEVELOPMENT OF THE MODERN PRINTER'S DEVICE

Nearly every modern publisher uses a pictorial device or imprint on the title page of his books, which device soon becomes familiar to readers as the trade-mark of the house. This device is the modern survival of the medieval Colophon or crowning-piece, the certificate of the illuminator, which was put at the end of the book, as a painter's device is put in the corner of a picture and a stamp or seal on the bottom of a piece of silver or porcelain.

To understand the development of this device, it is necessary to go back to the period immediately preceding the invention of printing, when there was no title-page to a manuscript. When the name of the book had been written on its cover of vellum, as was customary, there seemed no need to repeat it inside in the form of a full page. Vellum and linen paper were of high price, and a full leaf may have been adjudged needless waste by the copyist who had been taught to compress letters and huddle words in an effort to save space. Whatever the reason, the custom was universal. The copyist introduced the manuscript book to the reader at the top of the page with the usual phrase of "Here beginneth * * * " (naming the subject-matter) and then he began to copy the text, which he often did without indicating the change by making a new paragraph. He rarely affixed his name at the ending of the book; many early manuscripts are without name, date or place mark. The illuminator who decorated the book with initial letters and borders in bright colors was not so modest: he added a paragraph at the end of the book in which he wrote his name and certified that his work was finished on a certain day in a specified place.

The first printers followed traditional usage: they did not use title-pages and some of them did not put their names or any imprint on their books. In one of the earliest printed books, the "Bible of Forty-two Lines," supposed to have been printed before 1456, the usual beginning is at the top of the first page but neither on that page nor any other is there any mention of the date and place of printing or the name of the printer, but at the end of the book is the colophon of the illuminator in writing. In a Psalter of 1457, accepted as the first book with a printed date, the printers followed the custom of the illuminators and added a colophon in type in which they advertised themselves as makers of books by a new process and they made their advertisement conspicuous by a pictorial device.

The printers of this period, however, chose to have their books impersonal, and many books were issued without place and without name, but many reasons developed why a printed book should not be impersonal. Careful printers wanted their work distinguished from that of careless printers; piratical printers stole the works of others and issued faulty reprints at a lower price, so it was not long before the critical reader began to discover the relative merits of books and to look for the imprint of a reputable printer as some guarantee of its accuracy. A book without attest was like a bit of silverware without the official stamp; it might be good, it might be bad. By the end of the fifteenth century, reputable printers in all countries put their names at the end of their books, as, for instance, "Here endeth the book of witty sayings of Poggio of Florence, apostolic secretary. Printed at Antwerp by me, Matthew Goes, the third day of August, in the year of our Lord, 1487."

For some time thereafter the colophon passed through various stages of size of type, spacing and display. Some printers made use of it to extol the merit of their books and to brag of their superior ability as editors and greater skill as printers. Nicholas Jenson, one of the foremost printers of the time, carried this self-assertion to the obtrusion of his personal qualities. In one of his books appears his colophon as follows:

> Moreover, this new edition was furnished us to print in Venice by Nicholas Jenson, of France, a true Catholic, kind toward all, beneficent, generous, truthful, and steadfast. In the beauty, dignity and accuracy of his printing, let me, with the indulgence of all, name him the first in the whole world; first likewise in his marvelous speed. He exists in this our time as a special gift of Heaven to men. June thirteenth, in the year of redemption, 1480. Farewell.

*[illegible] A Treatise on Title-Pages. By Theodore Low De Vinne. The Century Co., New York, [illegible]

soon became dissatisfied with the tion and scant wording of the tradi-phon and tried to make it more at-y putting it in meter; others made ible by eccentric arrangements of h as the wine cup, funnel and full

ophon maintained its position at the book for many years and gave great to readers who would have to search act name of the book and its printer, ate and place of printing, in a petty at the end of the text, where it was ured by the index that followed.

Schoeffer was the first who provided fect by adding to his colophon a con-lack device. Other printers followed ple and had bold devices engraved intended to serve as seals to a sig-d as a reminder and means of quick n to book buyers who may have for-e names of their preferred printers. beginning this device was put at the e book, above the colophon. It was small and simple design in white, in round; but the eagerness to have a t would be striking led to its enlarge-afterward to an entire change of po-When the greater part of the last page cupied by the last paragraph of the device required a separate page. o making full-page devices and after-he putting of the device on the first

were objections to the device of solid kground; it was difficult to print with or of black; if the book were bound e ink had dried, the moist ink would color to the page that faced it; it lessly conspicuous and gradually was give way to engraving in outline. had increased in size to that of a, the query arose as to why the very page that contained the colophon e should be put at the end of the ere it could not be readily inspected. e importance of the title at the front ok was generally admitted, the change e slowly.

st efforts toward this change were the French printers. Their devices in wood or soft metal and contained of the printer in bold letters; but as intended to be used, not in one, but books of that printer, they did not ve the name of the books in which they appeared. To adopt them to a changed size of leaf, strips and pieces of decorative border were added to make them of the required sizes. The pictures selected for the early titles were usually in outline, so made in the belief that the buyer would fill up the white spaces with washes of bright colors. The pictorial device was taken up by the printers of other countries and soon nearly every printer had one, but few had artistic merit. In England that most in favor was a pun on the printer's name, or a description of his sign or of the house or street in which he worked. On the continent geometric and heraldic emblems were preferred. In an early book on typographical marks more than thirteen hundred devices were reproduced, and these were confined to books in the French language made by French printers before the end of the seventeenth century.

The repetition in different books of the same device became monotonous to the reader, as it did not always identify the printer nor did it specify the book. To meet this and other objections printers began to make smaller devices and to give more prominence to the name of the book and its author.

With the decline of printing in the seventeenth and eighteenth centuries may also be noticed the decline of the device. Books were often published without one, yet the need of a decorative spot on a bleak title-page seems to have been felt by the printers of every nation. Some inserted on the title-page old wood cuts that were often inappropriate; others made use of an emblem or an unmeaning decoration of a basket or pot of flowers. Many years passed before the title of the book and the name of the author received rightful prominence, and the publisher became content with his name at the foot of the page, in type of proper subordination. Publishers improved the appearance of the page by suitable devices which, in most cases, had a significance connected with their work. Many of the modern devices are adoptions of those of the early printers, or a pun on a name, or an adoption of a monogram.

One peculiarity of the old colophon is not yet out of fashion in England: there the printer of a book still puts his name at the end of the work, while the publisher has gone to the front. In America, the name of the printer is usually at the back of the title-page, which page also contains the notice of copyright.

AMERICAN AND BRITISH PUBLISHERS

THEIR "TRADE MARKS" AND SOME INTERESTING DATA

With the idea of preparing an article on "Publisher's Trade Marks," Technical Literature asked the leading publishing houses of the United States and Great Britain for information regarding the date of establishment, etc., that would be of interest to readers of books, both general and scientific. There was a prompt response to this request, but while it was not large enough to make the list complete, it was sufficient to justify tabulating the information for this issue of Technical Literature.

Nearly all publishers use a device on the title pages of their books—a survival of the medieval colophon, the origin and development of which is described in the foregoing article. To some readers these devices are merely ornaments with little or no significance, but many of them have become so familiar that the explanation of their significance cannot be without interest. In the following list of publishers, the marks show examples of the various types mentioned in the previous article. We have also given as fully as possible in the space at our disposal, the founder and present head of house, date of foundation, class and approximate quantity of literature published and any other specially interesting data.

AINSWORTH & COMPANY, Chicago, Atlanta and Toronto. (Franklin F. Ainsworth.) School books. Device used is the Ainsworth crest.

Established in 1838 as a partnership between Joseph Fessenden Ainsworth and William Crosby as Crosby & Ainsworth, which continued until about 1857 when Mr. A. S. Barnes replaced Mr. Crosby as partner. On the death of both partners the business was [illegible] with the American Book Company and [illegible] was [illegible] under present [illegible] [illegible] because Mr. [illegible] his [illegible]

AMERICAN TECHNICAL SOCIETY, Chicago. Founded in 1902 by R. T. Miller, Jr., present head of house.

Technical books; ten titles.

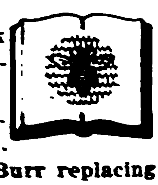
ATKINSON, MENTZER & GROVER, Chicago and Boston. Founded in 1898 by Charles F. Atkinson (now President of the corporation) and John P. Mentzer. School publications.

Device: Various types, but always the laurel, and scroll with motto "Esse quam videri," and monogram, the whole surmounted by a crown. Significance—To be rather than to seem; to ring true at all times; to pass at face value, whatever that may be; to be known for what you are and to be proud of it; to deceive no one, least of all yourself; this is indeed the kind of honesty that is the best policy.

HENRY CAREY BAIRD & CO., Philadelphia. (Henry C. Baird.) Founded 1785 by Mathew Carey. Technology principally—several thousand titles. First publishers making a specialty of this branch of literature, which was taken up in 1849. Use no regular device other than the portrait of the founder.

BAKER & TAYLOR CO., New York. (Nelson Taylor.) Founded 1830 by David F. Robinson and B. B. Barber; taken over by Mr. James S. Baker and Mr. Nelson Taylor in 1884 and incorporated in the present company. General literature—about 300 titles.

A. S. BARNES & CO., New York. (Henry Burr Barnes.) Educational and general literature—about 1,000 books.



Device shows an open book and a bee representing the industry.

Founded 1838 by Alfred S. Barnes and Chas. Davies; 1852, Barnes & Burr with Henry L. Burr replacing

Davies; 1865, A. S. Barnes & Co. with sons as partners. Burr deceased. Publish four educational journals.

BATES & GUILD COMPANY, Boston. Founded 1887 by Henry D. Bates, President of the Company. Business started in the architectural dept. of the Mass. Inst. of Tech. as Bates & Kimball; 1889, Bates, Kimball & Guild; 1892, Bates & Guild; 1897, company incorporated. Architectural publications.

Device is an architectural design consisting of a book on a capital.

P. BLACKISTON'S SON & CO., Philadelphia. Kenneth M. Blackiston, President. Founded 1843 by Robert Lindsay and Presley Blackiston. Literature on Chemistry, Biology and Medicine; about 300 titles now in press.

BROADWAY PUBLISHING CO., New York. Founded 1902 by Stephen G. Clow, present head of house. General literature; about 275 titles. Device, letters B. P. Co. in monogram.

WILLIAM J. CAMPBELL, Philadelphia. Publications: American History and Law, about 50 titles. Device used is the Campbell crest—Boar's Head with motto "Ne Obliviscaris" (never forget). Founded 1850 by John Campbell; 1871, John Campbell & Son; 1879, Wm. J. Campbell and since 1904 associated with John J. Campbell—the third generation.

THE CENTURY CO., New York, (Frank H. Scott, President). Founded 1870 by Roswell Smith, J. G. Holland and Charles Scribner. Publications—general; about 600 titles not including magazine.

Device represents an open book backed by a palette and rays of light, suggesting literature and art.

THE C. M. CLARK PUBLISHING CO., Boston and London. Founded in 1900 by C. M. C. Atkinson, present head of company. Books of fiction; 52 titles.

Device — French motto, "Success is a duty."

WILLIAM T. COMSTOCK, New York. Founded 1865 by A. J. Bicknell at Springfield, Ill.; moved to New York 1867, and firm became A. J. Bicknell & Co.; 1877, W. T. Comstock entered firm; 1880, named changed to Bicknell & Comstock; 1882, Mr. Bicknell retired and present firm succeeded.

Monthly periodical and architectural books; about 200 titles.

THEODORE L. DE VINNE & CO., New York. House founded in 1836 by ———— Plows, an English printer. Not publishers but printers for some of the largest and best known publishing houses. T. L. De Vinne, head of the company, is the author of several standard works on typography.

Device used in private work represents part of a scroll with Greek inscription quoted from Greek dramatist, Aeschylus, in which he defies Prometheus, chained to a rock by order of Jupiter, having been charged with snatching fire from heaven. In enumerating the benefits he had conferred upon mankind, Prometheus says: "—— and further, I discovered for them numeration, most striking of inventions; and 'composition,' nurse of the arts, producer of the record of all things."

M. A. DONOHUE & CO., Chicago and New York. Founded 1864 by M. A. Donohue. Non-copyright literature; about 1,100 titles.

DOUBLEDAY, PAGE & COMPANY, New York, Chicago, London. Founded 1900 by Frank N. Doubleday, now president of the company. Publish fiction, technical, nature and general literature; about 500 titles.

Device consists of an open book in a decorative shield, with the motto "Fructus quam folia"—"Fruit rather than leaves," signifying books of real value rather than mere printed paper.

FREDERICK J. DRAKE & CO., Chicago. Founded in 1902 by Frederick J. Drake. Technical and miscellaneous books, about 200 titles.

Device: an American eagle with outstretched wings protecting and proclaiming universal knowledge, symbolized by a wheel upheld by claws of eagle and containing in its center a book bearing the monogram of the company. Beneath is a script with the motto "Knowledge is power."

DUFFIELD & CO., New York. Founded 1903 by R. K. Fox and Pitts Duffield. General literature; about 350 titles.

Device consists of the laurel and apple; motto "Fide et literis" and monogram.

E. P. DUTTON & CO., New York. Founded 1852 by E. P. Dutton. Juvenile and General Literature.

THE ENGINEERING NEWS PUBLISHING COMPANY, New York and Chicago. Founded in Chicago in 1874 by George H. Frost, now President of Company. Business transferred to New York in 1878. Company incorporated 1883. Publishers of "Engineering News" and engineering books; about 90 titles.

Device represents a wax seal with name of company and date 1874. Used on paper covered books and pamphlets, but designed principally for use on a bookplate.

FUNK & WAGNALLS COMPANY, New York and London. Founded in 1876 in New York by Isaac K. Funk, who is still President of the company. Publications are educational, general, and periodical, about 1,800.

Device represents Minerva, Goddess of Literature, kneeling at lighted lamp before an open volume. Columns on either side show monogram inscription of F. & W. Co.

GRAFTON PRESS, New York and Boston. Founded 1901 by Frederick H. Hitchcock, present head of house. Historical, genealogical and specialized books; about 200 titles.

Device consists of a double pun on the name of Grafton: the "grafted" tree and the "tun" with the motto "Suscipite insitum verbum" from the Vulgate edition of the Bible (James I.), meaning "Receive the engrafted word." This device was used by Richard Grafton, for whom the firm has been named and who was an English printer and writer of great prominence during the reigns of Henry VIII and Edward VI.

HARPER & BROTHERS, New York, London, and several American cities. (George Harvey.) Literary periodicals and general books—about 10,000. Founded in 1817 by James and John Harper, under the firm name J. & J. Harper; in 1833 present name was adopted when two other brothers were taken into partnership.

The device, adopted early in the history of the house, represents a torch being passed from one hand to another—a metaphor originating in the old Greek torch-race where one runner strove to pass a blazing torch which he carried to the next, without extinguishing it. The Greek quotation is from Plato's "Republic," meaning "Those who have torches will pass them on to one another." The significance is obvious—handing down the light of literature and knowledge from one generation to another.

D. C. HEATH & CO. (Incorporated), New York, Boston, London and branches in several American cities. Founded in 1886 by D. C. Heath, now President of the corporation. Educational, scientific and mathematical literature; about 1,500 titles.

HILL PUBLISHING COMPANY, New York. John A. Hill, President.

Founded in 1896 when Mr. Hill purchased the "American Machinist." Later purchased "Power" and "The Engineering and Mining Journal." Also publish scientific books, principally mining.

Device, recently adopted, represents a crane hook significant of a line of publications including manufacturing, power and mining.

HENRY HOLT & COMPANY, New York, Chicago, San Francisco, Boston. Henry Holt, President. Founded 1858 by Frederick Leypoldt; incorporated 1903. Text-books, scientific and general literature; about 1,100 titles.

Device: an owl, Minerva's bird, hence the bird of wisdom; motto "Not many but much," signifying "not quantity but quality."

The predecessors of the present corporation were Leypoldt & Holt; Leypoldt, Holt & Williams, and Holt & Williams. The original partnership was brought about through a friendship commenced by the rejection of a manuscript of Mr. Holt's by Mr. Leypoldt.

LAIRD & LEE, Chicago. (Wm. H. Lee.) Founded, 1887, by Mr. Lee and Fred. C. Laird. School Books, Technical, Fiction and Dictionaries; about 500 titles.

Device signifies Literature as the sun shedding its light upon the world. L. & L. of Chicago, represented by the three branches of the Chicago River, working in the service of literature courageously, faithfully and with success.

JOHN LANE COMPANY, New York. (Rutger B. Jewett.) Miscellaneous literature, 2,000 titles. Founded 1896 by John Lane.

Device consists of portrait of Sir Thomas Bodley, founder of the Bodleian Library, Oxford. The second mark is used in the periodical publications of the house.

J. J. LITTLE & CO., New York. Founded in 1867 by Joseph J. Little.

This firm does not publish on its own account, but prints for publishers.

Device represents the tree of knowledge, signifying knowledge of bookmaking.

J. B. LIPPINCOTT COMPANY, Philadelphia, New York, London, Montreal. Craige Lippincott, President. Founded 1792 by Jacob Johnson. Scientific and General.

Device, motto "Right and Forward"; rising sun of enlightenment; tree of knowledge; lamp of wisdom; open book; horn of plenty.

The business passed through many changes of ownership after its establishment — Jacob Johnson; Johnson & Warner; Warner & Grigg; Grigg & Elliot; Grigg, Elliot & Co.—until in 1850, it was purchased by Joshua B. Lippincott and became known as Lippincott, Grambo & Co. A few years later it was changed to the present name which has stood for half a century.

THE MACMILLAN COMPANY, New York, London, Toronto and other cities in United States, India and Australia. George P. Brett, President. Publish scientific and general literature. Do not have any special device, but use as an imprint the addresses of the various branch offices of the company.

THE McCLURE COMPANY. (S. S. McClure.) Founded in 1900 by present head of company. Fiction and miscellaneous literature, about 350 titles.

Device, representing a Dolphin and Anchor, is adopted from that of the great Italian printer Aldus, and the motto "Aldi discip Americanus"—American disciples of Aldus.

G. & C. MERRIAM COMPANY, Springfield, Mass., and Sydney, Australia. C. M. Baker, President. Founded 1831 by George and Charles Merriam. Publishers of Webster's International Dictionaries, which name is used as a registered trade mark. The original firm published law and religious books, but after the death in 1843 of Dr. Noah Webster, they purchased the rights to his "American Dictionary of the English Language," which has developed to the modern voluminous "International Dictionary."

WEBSTER'S INTERNATIONAL DICTIONARY

REGISTERED IN U. S. PATENT OFFICE

ISAAC PITMAN & SONS, New York and London. (Alfred and Ernest Pitman.) Commercial works, about 250 titles. Founded in 1837 by Isaac Pitman.

Device is a registered Trade Mark.

MOFFAT, YARD & CO., New York. (Wm. D. Moffat.) Founded 1905 by Wm. D. Moffatt and Robt. S. Yard. General literature—about 75 titles.

G. P. PUTNAM'S SONS, New York and London. Founded 1837 by George Palmer Putnam; 1866, present firm organized, of which George H. Putnam is head. Publications include history, biography, scientific, educational, medical and general literature.

Device involving placque with letters G. P. P. S. in artistic surroundings has been in use for fifteen years.

BENJAMIN H. SANBORN & CO., Boston, New York, Chicago. Founded 1898 by Benj. H. Sanborn. School and College text-books; about 200 titles.

SILVER, BURDETT & COMPANY, New York, and branch offices in several cities. Founded 1885 by Edgar O. Silver, now President of company, as a private business; 1886, Silver, Rogers & Co.; 1888, present name adopted as partnership and incorporated in 1892. Educational text-books; about 1,500 titles. Device, letters S. B. & Co. in monogram.

A. WESSELS COMPANY, New York. Founded 1902 by A. Wessels. Miscellaneous literature; about 300 titles.

Device, an adaptation of the mark of Jenson, the Italian printer, and a Latin motto "Convertite et proficiscere," which is a rather free translation of the Ghourki motto "Face to the front and keep going."

JOHN WILEY & SONS, New York. Wm. H. Wiley, President of the Corporation. Founded in 1807 by Charles Wiley.

Publish books in the fields of pure and applied science; more than 600 titles. Represent in America the publications of Chapman & Hall, Ltd., of London.

THE LITERATURE OF METHODS AND COSTS IN TECHNICAL WORK

By HARWOOD FROST

There is probably no one thing that gives the average consulting or designing engineer more trouble than obtaining definite and desirable data that can be used with confidence as a basis for estimating the cost of work. Second only to the desire for accurate cost data, or perhaps, primarily, in the opinion of some, is the desire for detailed information regarding successful methods of executing work; methods that have saved expenses, saved time, safeguarded life and facilitated constructive operations. This is especially the case where, as not infrequently happens, an engineer is called on to work in a field with the details of which he is not thoroughly conversant, when, manifestly, he cannot rely on his own experience, but must seek that of others. His first recourse is to the various technical publications, and his usual method is to begin a search through these to find what his brother engineers have put on record; and usually, it must be confessed, with very indifferent results.

Many of the professional papers or descriptive articles in the technical journals and in the proceedings of engineering societies are complete in every respect, except the vital one of stating methods, costs and prices. Why? We presume that the engineer and contractor considers that this information and data, often the accumulated result of many years' experience, form one of his chief assets and an important feature of the "stock-in-trade" on which he bases his reputation and consequent practice. On the other hand, it is altogether probable that in many cases this policy of secrecy regarding prices to which so many firms tenaciously adhere, is really based on nothing more than tradition, and that the publication of prices would react to the benefit more than to the injury of the engineer or the contractor.

of all available information along is evident. The engineer or con- is called upon to furnish an esti- given engineering work must know piece of work will cost to perform make a bid which will yield him a but which will not be so excessive he job. Yet a large proportion of contractors have no very definite of the cost of their work. As to hile information regarding them is alue, the facilities for performing operations as well as for handling are constantly undergoing such ges that much that was of use on is now out of date. It is almost to say that every piece of engin- contracting work is practically a ling for individual solution.

ng, then, the scarcity of methods formation and the need of it, and at there is plenty of it among the ers of contractors, why is there so ble? One reason is, as mentioned it is regarded by some as their "stock-in-trade." Another reason ned objection, on the part of a su- aving an assistant describe a piece d publish the cost figures, an objec- in the majority of cases entirely al business policy. In such a de- e employee naturally refrains from hat might be considered by his revealing private information, and is any doubt or question, he will erely on the chance that it might to. A third reason for the omis- t data is a failure on the part of eers to comprehend the usefulness to other engineers. Many engin- they sit down to write a profes- r, undertake the work from the t of view. What is wanted is not scription of a given piece of work ld be subordinate to the main pur- rding those facts and figures which rect practical use to other members ession. These facts should stand ntly and not be buried in the mass ive matter. On the other hand, d be a sufficient literary excellence the paper from becoming a dry cts and figures, and making it far tive than would be the same or information presented in such a t it compels the attention of the impresses the salient facts upon r.

Of these possible reasons for the scarcity of methods and cost data, the most important is the first; but taking all in all, a knowledge of costs is only one of the qualifications needed by a successful contractor and is probably the one of lightest weight, but one which he often considers as the heaviest. He overlooks or underestimates the qualities he possesses which he cannot pass on—his knowledge of when, where, and how to get capital with which to operate and where to secure bonds-men; his business ability and knowledge of how and where to buy; his knowledge of human nature; his power to organize and discipline his forces to secure efficient and harmonious work.

What was probably the earliest systematic effort to obtain and publish reliable cost data was made by the "Engineering News" some years ago, when it presented several articles dealing with the detailed cost of construction work. The interest thus awakened brought out in the following years the publication of many valuable records in both the "Engineering News" and other technical journals. Further, in some of the later technical books their authors have made it a point to include at least one chapter containing as much of this published information as relates to the subjects treated.

With the development of this specialty and the recognition of its importance came its specialized literature. The first and most important of this is undoubtedly Gillette's "Cost Data" (1905—$4.) The author had already written three treatises on particular features of engineering work, but in this book he attempts to cover as nearly as possible all classes of construction and to present it in such a manner as to allow of its application by both the engineer and the contractor.

The book is divided into fourteen sections, under heads that facilitate quick reference, such as "Cost of Earth Excavation," "Cost of Stone Masonry," "Cost of Concrete Construction of All Kinds," etc. In his preface, the author claims a distinction between this book and books on prices of materials and contract prices. He points out the difference between a "contract price" and a "contract cost" and shows that in order to understand any analysis of costs it is necessary to know the methods used in construction and operation and the local conditions. Not only does this book give actual cost data, but it devotes one section to an explanation of the systems of cost keeping, the preparation of estimates, organization of forces, and much miscellaneous

information of value to both old and young contractors.

One of the faults of the majority of articles on costs is the statements in regard to wages; in many cases, figures dealing with wages are omitted, which is but natural when it is considered that wages are subject to constant fluctuation. In his "Cost Data," Mr. Gillette has stated the rate of wages only when it was possible to explain the conditions under which the work was performed. This book may be considered as the genesis of books of the kind; it has so far had practically no competition, and while it gives much information, costs are constantly changing, a condition that will probably be met by future editions, enlarged and brought up to date.

Gillette's "Earthwork and Its Cost" (1903—$2.00) is one of the three books preliminary to the author's "Cost Data." In it, he makes available not only his own notes on the subject and his gleanings from a careful examination of a wide range of engineering literature, but also much data obtained directly from engineers and contractors, which had not been previously published. He discusses in the introductory chapter the "Art of Cost Estimating" and after quoting a number of examples to show how liable engineers are to underestimate the cost of work, fifteen causes of underestimates are given, which are then discussed briefly.

Gillette's "Rock Excavation—Methods and Cost" (1904—$3.00) may be considered as a companion and complement of "Earthwork and Its Cost." When it was published it was considered one of the most important engineering works of the year. There is hardly any kind of construction work in which the problem of excavation of earth or rock is not the first to be considered; and in this book the subject is presented in such detail and given with so few technical terms, that not only can the book be used as a students' text book, but even a contractor's foreman, who may not be overmuch of a book reader, will find the volume of interest as well as of vast benefit.

It deals with every variety of rock excavation: open cut, trench, tunnel, and loose material; quarrying, railroad and canal work; subways, prospecting, mining, shaft sinking, drifting, sloping, subaqueous excavation, and boulder breaking are also treated. For each class of work a number of records of costs are given, and as far as possible a detailed description accompanies the records. Various methods are explained in detail and pointed and useful comment is frequently made upon the given method.

Gillette's "Economics of Road Construction" (1901—2d Edition, Revised, 1906—$1.00) is a monograph dealing with earth, gravel, macadam and telford roads, and repairs, maintenance, etc.

Among books devoted specially to the subject of cost data is:

Arthur's "The Building Estimator" (1905—$1.50)—a small handbook of 184 pages in which the author has crowded a great deal of valuable information covering a wide range of subjects. It is published in Omaha, the residence of the author, and much of the data are based on the ruling prices of that district. At the same time, the book appears to be the most complete of its kind yet published.

Other books along the same line are Hodgson's "Builders' and Architects' Modern Estimator" (1904—$1.50) and Hodgson's "Estimator and Contractor's Guide" (1904—$1.50) which describes methods of pricing builder's work, and Kidder's "Architect's and Builder's Pocket-Book" (Revised, 1904—$5.00).

A number of books of more or less value have been published, dealing with various phases of manufacturing costs, but the majority confine themselves to the systems of finding costs instead of the actual cost figures. One of the faults to be found with many of these as well as with nearly all works dealing with methods and costs is the lack of new and revised editions to bring the data up to date.

Among books of this class are:

Metcalf's "Cost of Manufactures and the Administration of Workshops, Public and Private" (3d Edit.—$5.00).

A system of mechanical bookkeeping based on the card catalogue method, by which the cost of manufactures may be promptly determined.

Arnold's "Complete Cost Keeper" (3d Edit. 1904—$5.00) explains some systems of factory accounting and the advantages of account keeping by means of cards, and gives descriptions of various mechanical aids.

Arnold's "Factory Manager and Accountant" (1903—$5.00) gives some examples of latest American factory practice.

Garcke and Fells' "Factory Accounts" ($3).

Hall's "Manufacturing Costs" (1904—$3).

Reeves' "Cost of Competition" (1905—$2).

Strachan's "Cost Accounts" (1903—$1.50).

illiner's "Cost Accounts" ($5.00).

att's "Cost of Production" (1902—$2.00).

oods' "Organizing a Factory" (1905—
)).

wn's "Mine Accounts and Mining Book-
ing" (1906—$4.25).

Engineering Estimates, Costs and Ac-
ts" (1907—$4.75).

skold's "Engineer's Valuing Assistant"
Edit.—$3.00).

rry's "Office Management" ($4.00). A
book for architects and engineers.

ere have also been numerous small
phlets on the same subject, such as
r's "Importance of Cost Keeping to the
afacturer" (25 cents) and "Factory Cost
unts" (50 cents).

nong the more specialized books are
ards' set, "Cost of Food" (1906—$1.00),
t of Shelter" (1905—$1.00) and "Cost of
g" (1905—$1.00).

ese are technical to only a limited extent
might perhaps better be classed with
s on finance, values, money, distribution
ealth or economics.

e various handbooks, such as Trautwine's,
's, Byrne's, give a limited amount of cost
, and many books touch on it merely in
ection with a portion of the subject
ed. Among these are:

auffer's "Modern Tunnel Practice" (1906
.50). One chapter is devoted to "Some
Upon the Cost of Tunneling." In this
ection the author states the objections of
actors to publishing their information for
benefit of others, and goes on to say that
any varying factors enter into the matter
sts that experience on one piece of work
t always a safeguard for the cost of other
seemingly similar work. He gives details
few cases, selected, he says, chiefly for the
ose of showing how such records should
ept. These cover a wide variety of work
nnel construction.

ll's "Car Lubrication" (3d Edit. 1901—
)). Cost of lubricants and lubrication.

odhue's "Municipal Improvements" (3d
1900—$1.75). Cost of sewers, and
other public improvements.

lwell's "Sewerage" (5th Edit. 1902—
)).

urston's "Manual of the Steam Engine.
II—Design, Construction and Operation."
Edit. 1902—$6.00).

Byrne's "Highway Construction" (5th Edit. 1907—$5.00).

Andrews' "Handbook for Street Railway Engineers" (2d Edit. 1903—$1.25).

Relative percentages of expenditures to gross receipts for street railways in Massachusetts.

Wright's "Designing of Draw Spans" (in 2 parts. 1898—$3.50).

Richards' "Compressed Air" (1895—$1.50).

Redgrave and Spackman's "Calcareous Cements" (2d Edit.—$4.50).

Ketchum's "Design of Steel Mill Buildings" (2d Edit. 1907—$4.00).

Ketchum's "Design of Walls, Bins and Grain Elevators" (1907—$4.00).

Reid's "Concrete and Reinforced-Concrete Construction" (1907—$5.00).

Perrigo's "Modern Machine Shop Construction, Equipment and Management" (1906—$5.00).

Brown's "Organization of Gold Mining Business" ($10.00).

Merrill's "Stones for Building and Decoration" (3d Edit. 1903—$5.00).

Prices of stone and cost of dressing.

Taking up the subject of methods, technical books as a rule, treat to a greater or lesser extent the methods employed in certain lines of work, but there are few specialized books. Of these few, there are:

Douglas' "Practical Hints for Concrete Constructors" (1907—25 cents). A small reprint of two valuable articles that appeared in Engineering News, in which the author gives some general methods of design which govern first-class finished concrete work and general methods necessary in the supervision of this class of work to attain satisfactory results.

"Field System of Frank B. Gilbreth" is a book devoted entirely to methods, not entering at all into the field of costs. It contains the written ideas of the most successful men in the employ of one of the most successful general contractors in the United States. This book was originally issued by Frank B. Gilbreth for the sole use of his employees, the majority of whom were trained on the "duplicate part" system, in which foremen, superintendents and others can be transferred from one job to another without further training. The methods and rules laid down in this "Field System" form the basis of this training. The book is now offered for general sale by the M. C. Clark Publishing Company.

In periodical literature, almost all technical publications give more or less information, the greater quantity being published probably in "Engineering News" (New York) and "Engineering-Contracting" (Chicago). The latter is edited by Mr. Gillette, author of "Cost Data," and calls itself "Methods and Costs" paper.

Much of the information published in books gives approximations only which have but little real value in estimating actual costs of prospective work. The example that has now been set by these periodicals in giving details regarding current works should be followed by others. Both the engineer and the contractor will be benefited by the publication of such information, for the contractor who counts it as "stock-in-trade" is not only standing in his own light, but is attempting to hold back the wheels of progress. The contractor can educate the engineer, and the foreman will reap the reward and benefit from the engineer's knowledge.

BOOK REVIEWS

RECOLLECTIONS OF AN ILL-FATED EXPEDITION TO THE HEADWATERS OF THE MADEIRA RIVER IN BRAZIL.—By Neville B. Craig. In co-operation with members of the Madeira and Mamoré Association of Philadelphia. J. B. Lippincott Company, Philadelphia and London. Cloth; 5¾ × 8¾ ins.; pp. 479 + 12; 28 plates and 6 maps. $4, net.

Reviewed by ALBERT WELLS BUEL.*

Few tales of adventure surpass in general interest this account of an expedition of American railway builders, and not many equal it. It bears all the earmarks of accuracy. While the completeness and continuity of the story is somewhat sacrificed to the authenticated veracity of the historical account, it will, nevertheless, appeal to most lovers of works on travels and adventure.

Chapter XVI. describes the sea voyage of the tugs "Juno" and "Brazil," 85 and 95 ft. long, respectively. Although little more than the record of the "Brazil's" log, it is full of thrilling and dramatic incidents. It is difficult to imagine how a more perilous voyage could end successfully. In fact they reached their destination in safety only by the skin of their teeth.

Chapter XL., entitled "The Wreck of the Metropolis," is a most harrowing account of a shipwreck given in quite full detail. In the concluding paragraph the author says, "He has given the facts, as widely published at the time, and each reader can decide for himself whether it was due to circumstances beyond human control, or to the same unpunished, grasping greed that, beyond all doubt, caused the 'General Slocum' holocaust."

Some exciting and sanguinary experiences on land are also related, not the least of which is that of Chapter XXV., "Our Anthropophagous Acquaintances." This should suffice to furnish dreams of tomahawks and scalping knives to the average small boy for at least a fortnight.

But the greatest value of the book is as a contribution to engineering literature. It may almost serve as a treatise on organizing and equipping engineering expeditions for tropical work, until an authoritative text-book on the subject is available. It should be read by every engineer and contractor engaged in operations in tropical countries, and will be of value to many others engaged on works in distant lands or far from a base of supplies.

While many of the lessons to be learned from Mr. Craig's book are negative, or "how not to do it," it contains a positive one of supreme importance to the success of any such enterprise, and that is the magnificent loyalty and esprit de corps displayed by the entire personnel of the expedition, the Italian laborers alone excepted. This is the characteristic that runs, like a warp, through the entire narrative, and which, wresting honor from failure, commands respect for the men of the ill-fated Collins' expedition. It and it alone accounts for the accomplishment, in much less than a year, against terrific odds and staggering handicaps, of

[illegible] miles of lines cut and surveyed through the forest.
[illegible] miles of projected location made.

* [illegible] Design and Fabrication of [illegible] Work [illegible] Office of [illegible] New York City

es of located line established on he ground and accepted by the ailway company.
es of located line marked on the round but not finally accepted by he railway company.
es of right-of-way, 100 ft. wide, leared.
es of grading completed or in rogress.
es in operation for construction rain.
es permanent main track laid.
es temporary main track laid.
es telegraph poles erected.
es telegraph line completed.
s-ties made.
dings erected at San Antonio.
tles, aggregating 1,453 ft., contructed.

able then than now on sanitary regulations and proper rations for tropical expeditions, but one would hardly have expected large quantities of salt pork to have been included, even in 1878. It would seem that, when operating thousands of miles from the base, lines of communication would be established before rushing in a large expedition, and not afterwards. But notwithstanding all these shortcomings and others, the persistency and determination of the engineers of the expedition would certainly have carried it to a successful conclusion, had it not been for the legal and financial difficulties interposed.

Mr. Craig has inserted some notes on malarial fevers in an appendix, which should

AP OF PART OF SOUTH AMERICA, SHOWING GENERAL LOCATION OF MADEIRA & MAMORE R. R.
(Drawn from a map compiled by the Amazon Steam Navigation Co., Ltd.)

of an expedition with such a have attained the highest emieir profession, as have O. F. . Buchholz, F. A. Snow, Wm. C. o. W. Creighton and C. S. De s naturally to be expected.

ble that the financial arrangenot scrutinized as carefully as e at the present time before emuch an enterprise, but with the $4,000,000) in the bank of Eng- t, and under the jurisdiction of England, it is hardly surpris- & T. Collins failed to anticipate n of the concession by Bolivia, er own interest and the unfavorof the English Court of Appeals of the trial justice.

y less information was avail-

prove of some value, but papers on the same subject presented at the International Congress for Hygiene at Berlin, Sept. 22 to 29, published in Engineering News of Oct. 24, would be a valuable addition to this appendix if the book runs to a second edition, as it deserves to do.

The narrative suggests several other questions of hygiene that might have been briefly treated in similar appendixes, thus enhancing the value of the book, such as discipline and importance of avoiding unnecessary exposure or waste of energy; provisions for sanitary conditions, baths, aseptic and antiseptic preventives, etc.; protection from and treatment for stings of insects and parasites; advantages of adopting certain customs of the country ("Costumbres de pais") and provisions for habitations at permanent camps or

headquarters. Preliminary expenditures for such conveniences will prove to be good investments, if carried to the proper point and not too far. They were carried too far in at least one case, where a contractor, in a tropical country, established and maintained a camp that could best be described as a summer resort and the employees showed their appreciation by riding the stock to death on Sunday junkets, causing curtailment of working capacity during the first part of every week, and the loss of several valuable animals. The contractor was bankrupted as might have been expected.

The maps are excellent, and the illustrations very good indeed, considering the state of the art of photography in 1878, and the 29 years intervening. With portraits of nine of the promoters and members of the expedition, one is inclined to regret the modesty of the author in omitting his own.

THE STEAM ENGINE AND OTHER STEAM MOTORS.—A Text-Book for Engineering Colleges and a Treatise for Engineers. By Robert C. H. Heck, M. E., Assistant Professor of Mechanical Engineering, Lehigh University. In two volumes. Volume II: Form, Construction and Working of the Engine; The Steam Turbine. New York: D. Van Nostrand Company. Cloth; 6 x 9 ins.; pp. 678; 698 illustrations, mostly in the text. $5.00, net.

Reviewed by WILLIAM KENT.*

The first volume of this treatise was published in 1905. It covered the subjects of Elementary Thermodynamics, the Theory of the Steam Engine, the Action of Steam in the Engine, the Steam Jet, the Entropy Temperature Diagram and the Mechanics and Kinematics of the Engine.

The present volume treats of several other subjects connected with steam-engine theory and practice. The first fifty pages are devoted to a general description of different types of engines, including about forty cuts, mostly half-tone reproductions of photographs of complete engines. Many of these are taken from builders' catalogues and they merely give views of the general external appearance of the several engines.

Then follow fifty pages of descriptions of cylinders with numerous wax-process line drawings giving cross-sectional views. These are followed by a detailed description, covering about seventy pages, of the several parts that enter into the construction of the engine, such as pistons, piston-rods, cross-heads, guides, connecting-rods, shafts, cranks, crank-discs, bearings, fly-wheels, etc. Numerous drawings are given, many of them dimensioned. The form only is treated, no attempt being made to discuss strength, bearings, surface pressures and the like.

Valve-gears and their action form the subject of the next chapter. The Reuleaux and the Zeuner diagrams are treated at length. The Stephenson link motion is fully discussed and the Walschaert and Joy gears very briefly. Many forms of valves are illustrated, together with valve-gear details, including eccentrics, Corliss valve-gear for various forms, poppet valves, gridiron valves, etc.; also valves of direct-acting pumps, air-brake pumps and steam hammers. This chapter covers 190 pages and has 193 cuts. It forms a treatise of valves and gears which might well have been published in a separate volume. It is very complete in its descriptive matter, but the treatment of the Zeuner diagram does not seem to be as clear as that in some other books on valve-gear. The Sweet and Bilgram diagrams are not mentioned.

Governors form the subject of the next chapter of seventy pages. The kinematics and centrifugal force and inertia effects of the shaft governor are treated mathematically and the chapter will be found difficult for most readers.

The next chapter is on steam action and the multiple-expansion engine. Much space is given to the study of combined diagrams, and the chapter contains a good deal of mathematics and theoretical discussion. It is a very thorough treatment of the subject, illustrated with many diagrams and tables of results from practice. The ratios of cylinders are fully treated. No other book of which the writer has knowledge goes so deeply into the subject.

The steam turbine is next treated in about eighty pages, including descriptive mechanics of the jet, mathematical treatment of the theory, results of actual performance and design and construction of the leading turbines. The treatment is quite satisfactory, considering the small amount of space devoted to it.

The last chapter of the book is on steam-engine performance. It contains a table, covering twenty pages, of results of tests of a great number of engines of different forms, including the records of the most recent high-duty pumping engines. Very full data are given in regard to all these engines and the table is, by far, the most complete one of its

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*Dean and Professor of Mechanical Engineering of the *L. C. Smith* College of Applied Science, Syracuse University, Syracuse, N. Y.

'he results shown in the table are dis-
ind useful conclusions drawn from
A few curves showing the range of
at different loads deduced from the
re given.

e whole the book will be found very
as a reference book for practical en-
and students. The two volumes are
being a complete treatise on the steam
and they are scarcely suitable for text-
ut, for reference books, they are to be
nded as giving a better and fuller
it of some subjects than can be found
f the older works on this subject. We
few grammatical errors such as "there
data" on page 607 and "data that is"
609. The author seems to use "data"
ainately in both singular and plural,
is the correct expression "these data"
page 629. On page 602, we notice a
rd, "differino," which is not found in
tury dictionary.

TURBINES.—Practice and Theory.—
Lester G. French, S. B., Mechanical
;ineer, formerly Editor-in-Chief of
ichinery." Brattleboro, Vt.: The Tech-
l Press. Second Edition. Cloth; 5¾ ×
ins.; pp. 418; numerous text illustra-
s and tables. $3, net.

is an unusually satisfactory book in
theory and well-chosen practice are
sly balanced, and unnecessary ampli-
avoided. It opens with a chapter on
damental principles of steam turbine
n, in which the differences between
ous types are clearly stated. This is
l by some 45 pages which review the
ork done on turbines and the patents
hereon. The six succeeding chapters,
ng over 100 pages, are given up to
strated descriptions of all the leading
n and many of the principal European
; the descriptive matter having been
l in person by the author, excepting
case of European machines, where it
pplied by the makers themselves.
s IX. and X., comprising 45 pages, are
to a study of steam turbine perform-
d a comparison of the rates of steam
tion of turbines and reciprocating en-
nder different running conditions, in-
a discussion of the effect of variable
superheated steam, high and low
overloads, etc. Chapter XI. recounts
ous experiments which have been con-
n regard to the flow of steam through
and orifices, with the formulas de-
erefrom. The various *properties* of
steam, both saturated and superheated, together with a discussion of temperature-entropy diagrams, are given in Chapter XII. The next chapter takes up calculations on the flow of steam, and gives methods for the design of nozzles. Chapter XIV. discusses vanes for the different types of turbines, and the following one is devoted to a study of cylindrical bodies rotating at high speeds, and the methods used in balancing. Chapter XVI. considers questions of efficiencies and design, an example being worked out for a 500-KW. multicellular turbine. The next two chapters are devoted to care and management, and to the condensing apparatus used when high vacua are employed. The work closes with a brief chapter on the status of the marine turbine.

THE STEAM ENGINE AND OTHER HEAT MOTORS.—By W. H. P. Creighton, U. S. N. (Retired), Professor of Mechanical Engineering, Tulane University of Louisiana. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 5⅛ × 9¼ ins.; pp. 499; 198 illustrations in the text and one folding plate. $5.

Reviewed by JOHN J. FLATHER.*

This is an excellent treatise on the steam engine written primarily for the use of engineering students, but containing a large amount of useful information of value to the practicing engineer.

An examination of the book shows that it is not a vade mecum of the steam engine. The author has had in mind the needs of the engineering student, and the matter is presented in a manner which is intended to train the student to think. This is the prerequisite in a text-book rather than the presentation of a mass of facts and data.

As the author points out in his preface, the principal value of text-books should be instructional, and the present work has been written with this in view.

Especial stress has been laid on fundamental principles, and the errors a student is liable to make are clearly indicated. Prolixity in details has been avoided and the author's broad experience as a teacher of engineering subjects has enabled him to present the matter with a suitable regard for sequential statement, which is of so much importance to the proper development of a subject. The book is essentially devoted to thermodynamics and the kinematics of steam-engine design, both of which subjects have been handled in an admirable manner. Judicious omission charac-

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terizes the work as a whole, and much is left to the instructor to amplify and develop from his own experience or individual preferences. For instance, the history of the steam engine has been omitted entirely, and properly so in a work of this character; but it is questionable whether the omission of a discussion of the steam engine as a machine is justifiable.

The presentation of a bird's-eye view of the whole subject of steam plant is excellent, but to the present reviewer it seems hardly logical in a work on the steam engine to give figures of pumps and condensers, accompanied by a list of parts, without giving similar figures and discussion of the steam engine, which might well be extended to include a brief description of some of the characteristic types of engine. The author evidently intends that the student shall become familiar with these types and forms, as well as with the details of construction, by actual inspection of existing engines or otherwise; but it frequently happens that these outside sources are not available or are inconvenient of access, in which case a chapter devoted to a discussion of the steam engine as a machine would make the present treatise of more general value as a book of instruction.

The work starts out with a general view of the steam-engine plant and a brief review of elementary principles of the physical laws which relate to the steam engine. This is followed by a discussion of the indicator and indicator diagrams in which the rules for point of cut-off, ratio of expansion, horse-power and so forth, laid down by the Committee of the American Society of Mechanical Engineers, have been incorporated.

In the study of valve gears which follows, both the Zeuner and Bilgram methods are given briefly but clearly, and numerous examples are presented which add much to the value of this part of the subject.

Chapters V. to VIII. inclusive, which comprise about one hundred pages, are devoted to a consideration of the general principles of thermodynamics, in which the effects of heat and heat interchange are discussed. The Carnot Cycle, Hirn's Analysis, Entropy, Thermal Efficiency, and other generally accepted phases of the modern conception of the subject, are presented logically and sequentially. The student is brought step by step into a complete knowledge of the laws of thermodynamics, which are subsequently applied to the steam engine as well as to the gas engine, steam turbines, and refrigerating machines.

Condensers, air pumps and other auxiliary apparatus are discussed at length in Chapters IX. and X. This is followed by a brief history of compound engines and a discussion of multiple-expansion engines, in which the drawing of indicator diagrams directly from round numbers is shown. The convenience of this method readily permits the different points on the diagram to be found, and enables one to see at once the effect of any change, by a variation in the area of card.

The subject of engine regulation is discussed in detail. The author divides this into Revolution Control; and Speed-Variation Control; in which shaft governors and valve gears are studied in Chapter XII., and inertia effects in Chapter XIII. The subject is covered in an admirable maner and its treatment from the point of view of the engine designer is excellent; it is unfortunate, however, that the author did not carry the discussion on shaking forces and counter-balancing a little farther so as to include a consideration of the proportions of the weights and forces which are actually balanced under the different conditions which are in practice. Of the remaining chapters, Chapter XIV. is devoted to steam-engine tests, in which the A. S. M. E. standard rules are given. Superheated steam and steam turbines are considered in Chapter XV., in which about fifty pages are given to a discussion of the general principles of turbines and a description of the various well-known types of machine, including the De Laval, the Curtis, Parsons and the Holzwarth.

Brief chapters follow on gas engines and gas producers, and also on refrigeration; but in these the presentation is too brief to be of much value to the student, unless supplemented by a large amount of lecture work on the part of the instructor.

The chapter on Boiling in a Vacuum is undoubtedly of interest and value to the chemical engineer and those who may be engaged in the sugar and certain other industries; but to the present reviewer, it seems out of place in a treatise on the Steam Engines and Other Heat-Motors.

An Appendix contains a number of well-chosen tables which are of value both to the engineer and student.

PLANE SURVEYING.—A Text-book and Pocket Manual.—By John Clayton Tracy, C. E., Assistant Professor of Structural Engineering, Sheffield Scientific School of Yale University. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Flexible leather; 4 x 6 ins.; pp. xxvii + 794; with many figures in the text. $3.00.

While there are already several excellent manuals of surveying, there seems to be a field

new work, which is in many ways dif- from the others. It has been written the requirements of certain new meth- teaching surveying, especially of those s developed in summer courses where f the instruction formerly given in the om has been transferred to the field. Preface, the author explains the need of specially suited for these summer . He says: "Oral instruction is pecu- nadequate in field work where the stu- re more or less widely scattered, while ns and suggestions if given in the class- re frequently misunderstood or forgot- ore they can be applied in the field. The a is not solved by issuing a printed col- of exercises in which successive steps lined, for students are apt to follow the blindly and thus to defeat the end in It would seem better to provide a book h explicit directions for methods of pro- are supplemented by the same explana- nd comments as the instructor endeav- give orally."

present work is intended to realize this d. In plan it is a text-book and pocket combined, while in scope its aim is not r the whole field of surveying, but to ith thoroughness fundamental principles thods. As a text-book, it deals with the of surveying, while as a manual it gives practical suggestions and directions re usually left for oral instruction.

book is not the result of deliberate and ly planned work on the part of the au- ut rather of a painstaking and patient ng of questions asked, mistakes made ficulties encountered by students in suc- classes during several years of experi- the field. By keeping a card-index of ata, the needs of the students were as- ed, with the result that a pocket manual epared five years ago by the author for of his own classes. Yearly editions of nual have been issued with changes and ns suggested by new records in the card- until now it is offered in its present or general use.

book is primarily intended for students though it may be helpful to men in work, it goes more minutely into de- n seems necessary to such men. It has ade as convenient as possible for ready ce, so that the student may turn quickly part of the subject, but it is not ar- in the progressive order of most man- The arrangement that has been followed is the grouping of closely related chapters and topics in these parts: Field Work, Office Work, Surveying Instruments, and an Appendix of Tables.

In Part I., every branch of field work is treated under three general heads, viz.: the use of the instrument, the general method of procedure, and the practical details of field work; this arrangement is made to prevent any obscuring of the methods of procedure by directions for the use of the instrument, or vice versa, and to separate that part of the work which can be studied in the class-room from that which is better studied in the field.

The author calls attention to several special features, among them:

That the system of explaining the general methods of surveying under the head of compass surveying has been abandoned, and the whole theory of horizontal control is explained in connection with transit surveying, the innovation being justified by the fact that many engineers seldom, if ever, have occasion to use the compass.

That general statements of important principles and methods are almost invariably supplemented by special applications or practical illustrations.

That when there are two or more methods of doing the same thing, they are given one after the other and then compared.

That throughout the book special effort has been made to give a systematic and practical discussion of the subject of errors.

That no space has been wasted in describing and illustrating visible parts of instruments, but a critical study is made of their construction and adjustment, and a very complete chapter is given on their care.

The work concludes with an unusually ample and detailed index of thirty pages.

DESIGN AND CONSTRUCTION OF DAMS. Including Masonry, Earth, Rock-fill, Timber and Steel Structures, also the Principal Types of Movable Dams.—By Edward Wegmann, C. E., M. Am. Soc. C. E., author of "The Water Supply of the City of New York, 1658-1895." Fifth Edition, revised and enlarged. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 9¼ × 12 ins.; pp. xiii. + 421; illustrated with 120 text figures, and 133 full-page plates; 25 tables. $6.00.

The first edition of this work was published in 1888 as a treatise on "The Design and Construction of Masonry Dams." It contained the results of the studies made by the author

while engaged in making calculations for the design of the Quaker Bridge Dam, and information concerning high masonry dams built in various countries. The book passed through three editions with very slight changes or additions. In the fourth edition, published in 1899, the work was enlarged so as to include the whole subject of dams, viz., masonry, earth, rock-fill, timber structures, and the principal types of movable dams. At the time of publication the new Croton Dam was under construction and full specifications were given, also an explanation of the methods by which the profile of this dam was calculated.

In preparing this fifth edition, the author has thoroughly and carefully revised the entire book with the view of bringing the information as much as possible up to date. The newest theories proposed for the design of masonry dams have been mentioned. Some parts have been entirely rewritten. Descriptions of all important dams built or in course of construction, of which there is any published record, have been given, and in the cases of the New Croton Dam, the highest masonry dam in the world, and of other noteworthy reservoir walls, the construction has been described with considerable detail.

The newly added matter includes descriptions of steel and reinforced concrete dams, high earth dams, Stoney sluice-gates and rolling dams. Altogether the new matter has involved an increase in the present edition over the Fourth Edition, of 93 pages of reading matter, 39 plates, and 45 text figures and an increase in price from $5.00 to $6.00.

As stated in its title, this work illustrates and describes the important structures of this type throughout the world and lays down the principles governing design, so far as science has revealed the law of internal stresses in masses of masonry. It is divided into three parts: Design and Construction of Masonry Dams; Earthen, Rock-Fill, Timber and Steel Dams; Movable Dams, and an Appendix. There are 33 plates in the text and 100 at the end of the book; in the Appendix is an interesting classified bibliography of the subject, giving some 350 references to books, pamphlets, government reports, and periodicals from all parts of the world.

This book has long occupied a position in the literature of its subject similar to that held by Drinker's "Tunneling" in its field that of a work to which the professional man or the student of the subject must refer to become thoroughly posted

STEREOTOMY.—By Arthur W. French, Professor of Civil Engineering, Worcester Polytechnic Institute, and Howard C. Ives, Assistant Professor of Civil Engineering, University of Pennsylvania. New York: John Wiley & Sons;; London: Chapman & Hall, Ltd. Second Edition. Cloth; 6 x 9 ins.; pp. 115; illustrated with 47 text figures and 22 folding plates. $2.50.

The first edition of this book, published in 1903, was the first practical text-book on the subject. There were several books treating of stereotomy to a greater or less degree, but they were many years old and failed to give practical examples of modern masonry structures and in some cases even failed to properly illustrate the actual works of their own day. In this work the authors do not claim originality, but have rather selected matter from older works, condensed it where necessary and possible, and have brought together much scattered material into one practical volume. The subject-matter covers a wide range and includes everything that the student is likely to have need for in his future work. In the present edition there are few changes; a new design is given for a wing abutment, and a few alterations in the treatment of the oblique arch.

Chapter I is in the nature of an introduction to the balance of the book. It gives a general discussion of building stones, quarrying, stone-cutting tools, methods of finishing the surfaces, definitions of parts of the structure, classification of masonry and general rules and specifications for masonry work. It is to a large extent a digest of information contained in other books, but is valuable as bringing together for easy reference by the student, the terminology of the subject.

Chapter II gives definitions of stereotomy and classification of structures. It deals with the preparation of drawings of the entire structure and its parts; methods of cutting stones and the directing instruments used in cutting plain, cylindrical, conical and warped surfaces and the order of applying these tools; methods of making plaster casts of stone forms. The authors advocate, as a valuable exercise in connection with the study of the various problems in stereotomy, the cutting from blocks of plaster some of the stones called for in the drawings.

Chapter III gives the solution of problems in plane-sided structures, such as a buttress, a recessed flat arch, a bridge pier and bridge abutment, and architectural stone work.

Chapter IV treats of structures containing

developable curved surfaces such as erches of various kinds, geometrical constructions, ovals.

Chapter V discusses the oblique or skew arch, including the "false" skew, the ribbed skew and the helicoidal skew, and gives a bibliography of the oblique arch.

In Chapter VI problems of the recessed Marseilles gate, the hemispherical dome and the geometrical stairway are discussed.

The first two chapters are intended to give the student an outline of those features of masonry construction which must be in mind in properly drawing plans for stonework. The next two chapters contain the problems of most frequent occurrence, while the problems given in the last two chapters are of rarer occurrence, and for the most part are given in condensed form. Their most important value is in the mental training they furnish to the student.

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This work, now in its third edition, is a successful attempt to present the general principles involved in alternating-current engineering practice in a compact form, and without the use of the higher mathematics. The first part is devoted to an exposition of the general principles of magnetism and alternating currents employed in alternating work, in which such subjects as lines of force, phase, hysteresis, capacity, form and power factors, three-phase transmission, etc., are dealt with. Part II. takes up modern alternating-current apparatus, embracing the design, testing and use of the various classes of transformers; distribution systems; alternating-current motors of all types, and generators; also the testing of alternators for various characteristics and under various conditions. A chapter on the theory, use and testing of rotary converters concludes the book. Mr. Raymond's thorough conception of the needs of young engineers has enabled him to produce a book for their instruction that is a model of concise statement, clear expression, and concentration of purpose that could well be followed by others in the preparation of introductory texts.

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THE INDUCTION TYPE INTEGRATING WATT-HOUR METER.

By H. W. YOUNG.

The single-phase induction-type integrating wattmeter, now practically adopted as a standard for alternating current service, has steadily developed and been improved for several years, so that today it has practically superseded the older form of commutator-type meters employing wire-wound armatures. The design has been brought to such a point that little remains to be desired, as the meters can be used under widely varying conditions of voltage, load, frequency and power factor, and under these conditions are accurate to a degree never obtained with the commutator type of meter. In fact, the improvement in meter design has been so marked that stations heretofore heavily handicapped by the use of meters requiring heavy upkeep or maintenance charges and improper accuracy characteristics, have, by the adoption of the modern induction meter, been placed on a much better financial footing.

In tracing the development of the induction meter it is interesting to note that the most successful types have been those which incorporate the recognized fundamentals of design; namely, that the magnetic circuit must be so designed as to insure high accuracy under all conditions of load; that the revolving element must be of light weight; that the registering mechanism must be as near frictionless as possible and be free from corrosion; and that the lower bearing must be so constructed as to give low initial and ultimate friction. It is safe to say that a meter designer who ignores these fundamentals by employing improper electrical or mechanical design or unduly heavy moving elements will only succeed in producing an inferior type of meter.

One of the most successful types of induction meter is illustrated in Figs. 1, 2 and 3, showing front and rear views respectively, Figs. 2 and 3 showing the measuring element removed from the case. In principle and operation this meter is analogous to a single-

FIG. 1. INDUCTION TYPE WATT-HOUR METER, WESTINGHOUSE ELECTRIC & MANUFACTURING CO.

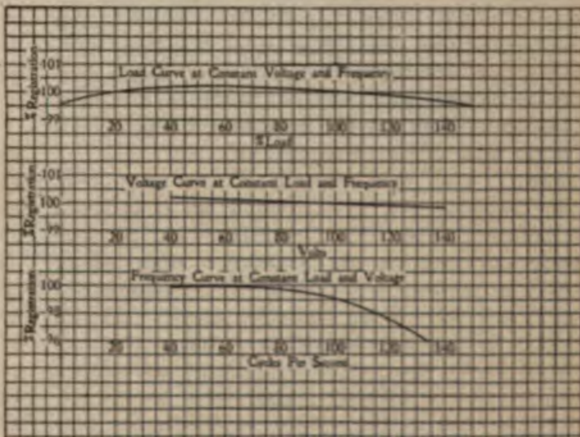

FIG. 4. PERFORMANCE CURVES OF INDUCTION METER.

FIG. 2. ELEMENTS OF INDUCTION TYPE METER.
(Rear View.)

A = Shunt coil mounted on iron laminations A'.
BB = Series coils mounted on iron ltminations B'.
C = cast-iron supporting frame.
D = Light-load adjustment.
D' = Balancing loop for D.
E = Permanent magnets mounted on support F.
G = Aluminum disk mounted on shaft.
I = Upper bearing.
J = Registering mechanism.
K = Power factor and frequency adjustment.

phase induction motor having a stationary shunt and series winding so related and located as to produce a rotating magnetic field acting upon a close rotable secondary, which in this design consists of a light, corrugated aluminum disk.

The shunt winding consisting of a large number of turns of fine wire wound on a laminated iron core, is highly inductive and its current lags approximately 90° behind the voltage of the line. The series winding, having but a few turns of heavy wire, has a low self-induction and with a properly designed measuring element the resultant fields of the shunt and series element are 90° out of phase. With this relation of the two fields the reactions are so combined as to produce a rotating field. This rotating field induces eddy currents in the aluminum disk which react to produce rotation in the same manner as in the rotor of an induction motor. As the rotary field is a combination of the series and shunt fields, the torque or turning movement on the disk is directly proportional to the energy flowing in the circuit to which the meter is connected.

With a driving torque proportional to the *energy flowing* in the circuit, it is necessary, in order to produce steady rotation, that a retarding torque be provided which will be proportional to the driving torque. This controlling force is secured by causing the aluminum disk to pass between the poles of permanent magnets whose fields induce eddy currents in the disk. The inter-action between the magnetic fields produces a retarding torque varying directly with the disk speed. By this combination of driving and retarding torques the speed of rotation is always proportional to the energy passing through the measuring coils.

In order that induction meters may be operated upon commercial circuits having wide voltage variations, it is necessary to so design the electromagnetic system that recalibration will be unnecessary to meet the varying conditions. In the design under consideration this is accomplished by so proportioning the leakage gaps that the greater portion of the magnetic lines are shunted and do not pass through or cut the disk. To determine that this successfully accomplishes the desired results it is only necessary to note the characteristic curve shown in Fig. 4. As will be seen, the meter will accurately register within the limits of 50 volts to 125 volts, thus

FIG. 3. ELEMENTS OF INDUCTION TYPE METER.
(Front View.)

illustrating the refinement of design attained. These curves are also interesting in that they also show a very satisfactory accuracy under varying loads and frequency.

To compensate the meter for the static and running friction of the moving elements, a so-called light-load adjustment is provided. This is accomplished by locating two closed copper loops in the leakage gaps of the potential coil, and the induced flux thus applies a constant magnetic field in the direction of rotation. By varying the position of these loops, more or less compensation may be secured, as found necessary.

In order to secure the highest possible initial and life accuracy it is essential that the rotating element be provided with a bearing which will give a minimum friction, and also be capable of giving a long life without impairment of its polished surfaces. This desirable feature has been secured by adopting a bearing which is a marked departure from the forms employed in the older forms of meters. The bearing consists of a highly polished steel ball located between two sapphire jewels, one of which is mounted on the rotable shaft and the other on a fixed jewel screw. As the disk revolves the ball moves from its initial position, giving a rolling action rather than the rubbing action of the older form of bearing. This changing point of contact gives a longer life and lower friction than can possibly be secured by the use of the rubbing or pivot type of bearing.

When this roller type of bearing was first introduced in meter design many people thought that it was a useless expense, inasmuch as two jewels were necessary, and therefore the jewel cost was double that of the older form of meters. Experience has proven that the adoption of the ball bearing was one of the highly important refinements in meter design, and service tests during the past three years have entirely sustained the claim originally made for this type of bearing. Meters have been run under service conditions and at such loads that the dials have registered 3,000 KW.-hrs., or, on the basis of 300 KW.-hrs. per year, the meters have performed a service equivalent to 10 years' ordinary lighting service.

At the end of the test the following results were secured: "All the meters were within 2% full load and 50% of the meters were within 2% at 2% of load. None of the remaining meters showed errors exceeding 5% at 2% of load." Such a showing is satisfactory, to say the least, and amply justifies the additional manufacturing expense attendant in securing this design of bearing.

A simple, practical method of analyzing the subject of meter bearings is to consider that in practically all moving machinery where minimum friction and light running is desired, some form of ball bearing is adopted; and a little thought will show that this is of even more importance in meters than in the moving element of the average machine.

The weight of the revolving element is one of the most important factors affecting jewel life, and therefore the initial and life accuracy of meters. With an increase or decrease of weight the jewel wear is correspondingly increased or decreased, and it will at once be apparent that the lighter the moving element the less friction will be present. The weight of moving elements employed by the different designers varies with wide limits, some employing elements weighing 45 grams, or approximately 1½ oz.; others employing 33 grams, or approximately 1 oz.; and in the meter under discussion the designers have succeeded in reducing the weight to 15 grams, or approximately ½ oz All of the earlier forms of meters employed comparatively heavy moving elements, but as the evil effects of such weights on jewel life became better known, designers have stead endeavored to reduce this weight to a minimum.

Owing to the fact that employing heavy disks (and therefore reducing the resistance to the induced currents) is one of the easiest and cheapest methods of securing a high torque or turning moment, many designers have been tempted to adopt this expedient rather than the preferable, although more expensive, method of developing a more efficient electromagnet system; but as the matter is becoming better understood, purchasers are beginning to demand long life with accuracy, and this demand will inevitably result in the abandoning of rotating elements having excessive weight.

During the past few years much discussion has been provoked over the relative importance of torque, ratio of torque to weight and ratio of torque to friction. Many have contended that this value alone gives no true indication of a meter's ability to give or maintain accuracy, and that before passing judgment it is also necessary to know the values of torque, weight of moving element, ratio of torque to weight and ratio of torque to friction.

Much time and discussion could be saved if the subject were treated in a simpler manner; that is, if the person in doubt would simply regard the meter as a miniature motor-generator set, in which the measuring coils and one edge of the disk constituted the driving motor, and the opposite edge of the disk in conjunction with the permanent or drag magnets were regarded as the driven generator. The work expended by the motor should (in order to give a perfect ratio between the motor and generator) be entirely expended in driving the generator; but it will quickly be seen that this condition is impossible, owing to the friction always present in the lower bearings, upper bearing and registering mechanism.

A meter might be so constructed as to have a torque of, say, 1,000 gram-millimeters; but with such poorly designed mechanical parts the larger part of the work would be expended in overcoming friction, and a comparatively small percentage would be expended in driving the disk through the field of the permanent magnets. Such a design could be secured by the use of a heavy disk, by expending a large amount of energy in the measuring coils or by employing both of these methods. The use of a heavy revolving element is fatal in its effect on jewel wear, and therefore accuracy of registration; the expenditure of large amounts of energy in the measuring system entails excessive and prohibitive watt losses, so that a little consideration will illustrate the fact that, in the last analysis, "the ratio of torque to friction" is the real determining factor. A high ratio of torque to friction, or in other words, a very large expenditure of work in driving the generator as compared to that expended in overcoming friction, can only be secured by the most careful electrical and mechanical design of the various meter elements; and among the most important of these is the actual weight of the revolving element and the type of lower bearing employed.

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Valter B. Snow, 170 Summer St., Bos-ss., who has lately severed his con-with the B. F. Sturtevant Co. to enter of advertising, has issued a booklet "Publicity Engineering," to which the g paragraph is the introduction.

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this equipment, supplemented by a rsonal acquaintance, he is in a posi-undertake the entire conduct of pub-r a number of manufacturers, limited, r, to non-competing lines, and by his o give personal attention to each.

osition occupied with relation to each ould be equivalent to that of pub-nager upon the regular staff, and the would include everything pertaining city—the design, placing, and check-rade paper advertising, the prepara-trade catalogues, fliers, and circular of special technical treatises, and the ion of photography, engraving, print-

service means that the entire burden ed from the shoulders of the manu-and placed in the hands of an ex-t means that in training and experi-expert naturally excels the ordinary manager, and all matter is written ngineer for engineers, and above all, result will be more productive pub-an if the advertising end of a busi-andled, as it is in many instances, by ployee who has a little time to spare then from other duties.

THE PUBLISHER'S CO-OPERATIVE COMPANY.

A Useful Adjunct to an Engineering Office.

This concern, which succeeds the well-known firm of Montgomery & Company, is what might be called a "literary shop." While its work is especially of value to publishers of books and periodicals, its usefulness to technical societies, professional engineers and manufacturing firms cannot be overlooked. The company lays stress upon its plans for centralizing in one organization the various departments of literary work usually conducted as separate enterprises. With a comprehensive development of each of these branches in special departments, and with the association of their workers in one company where the detail and routine are all referred to a central management,—the editor, the scientist,—the professional man in any calling, may be reasonably assured that all steps in the process of any literary undertaking entrusted to such a company will stand a chance of being more expeditiously,—and more consistently carried out,—than when the separate details of its preparation must be entrusted successively or piecemeal to different individuals and companies. This company does no publishing,—but in addition to its business of preparing, or helping to prepare,—matter for presentation to publishers, or lecture audiences, it makes it also its business to assist in finding publishers for authors, and in making arrangements for lectures. The lecture department concerns itself mainly with work in connection with clubs and societies for the discussion of arts and sciences, as well as of education, reform, and general progress, and is privileged to call upon a corps of lecturers authoritative in their chosen subjects.

The departments for General Research and Translation comprehend the bulk of detail work usually indispensable to the literary or professional man, and to the publisher, at various junctures in their undertakings. The General Research department covers encyclopedia compilation; indexing; literary science, with the preparation of biographies, and tabulations and classifications of miscellaneous subjects, and general editorial revision.

In the Translation department, special attention is directed to the accurate and idiomatic rendering of technical and scientific matter, and of belles lettres, and through the department special negotiations are made with

publishers for the translation of the current foreign literary output of importance.

Under the head of Special Research, the compilation of works on art, sciences and religions is undertaken, and the preparation of text-books. Through the Reviews department the company is prepared to arrange for the periodic contribution to current publications, syndicates and the like,—of reviews of literature, art, music and drama,—and of special articles upon topics of international and timely interest.

As a part of its own scheme the company has need of an advertising department, and this it places at the service of clients finding use for any of the multiple forms of publicity. Through its general corps of office assistants the company is prepared also to supply all miscellaneous routine service, as proof-reading, stenography, mimeographing, addressing, typewriting. A press-clipping service is included, and printing and engraving will be contracted for, and format in the best taste suggested and superintended.

In all departments the associate workers have been chosen for their recognized ability in the kinds of work planned for them.

The company, as a whole, is prepared to be a resource to publishers and professional men needing to supplement their own office resources from without, especially in the handling of large contracts and such as demand authoritative execution, and it is enrolled upon the editorial lists of the well-known publishing houses.

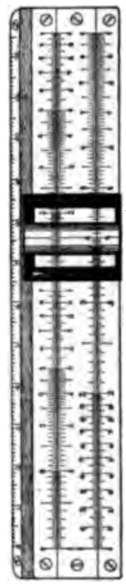
A. S. M. E. ANNUAL MEETING.

The fifty-fourth annual meeting of the American Society of Mechanical Engineers will be held in the Engineering Societies' Building at 29 West 39th Street, New York, on December 3 to 6, 1907.

Symposiums on foundry practice, giving the experiences of prominent men in that work, have been arranged. The specific heat of superheated steam will be taken up, and a very important and exhaustive paper by a professor of engineering at Cornell will be presented. The utilization of low-grade fuels in gas producers, combustion control in gas engines, tests of producer-gas engines, etc., will be given a session. Other live topics, such as industrial education, power transmission by friction driving, cylinder port velocities, etc., are to be discussed. All of these subjects have been treated by prominent engineers of Europe and America, professors of our universities, and men eminent in the particular work of which they write.

A CONVENIENT SLIDE RULE.

The illustration given shows the "Midget" Slide Rule which is manufactured by Kolesch & Co., 138 Fulton Street, New York.



Although its dimensions are restricted to only 5½ ins. in length, 1 in. in height and 5-16-in. in thickness, and its weight, including the case, does not exceed 1½ oz., it ranks in accuracy and reliability with the larger rules. The ultimate subdivisions are as fine as those on the regular 10-in. rule and by means of a powerful, yet compact and convenient magnifying glass their value is easily ascertained with the same percentage of accuracy as can be obtained by the 10-inch rule. These rules are made of the best built-up mahogany stock, with white facings, are engine divided, and each is provided with a sewed leather case with clasp.

HEATING AIR AND WATER.—Economical Heating for Breweries and Malt Houses. Green Fuel Economizer Co., Matteawan, N. Y. Paper; 6 x 9 ins.; pp. 16; illustrated.

The first seven pages of this booklet are devoted to a reprint of an article by Herr C. Eberle, of Munich, on "The Influence of Boiling by Steam on the Boiler Plants of Breweries," in which it is shown that the highest economy is reached only when both the exhaust steam from the different machines about the brewery and the waste gases from the boiler furnace are utilized for producing hot water. An example is fully worked out with diagrams and lay-out of machinery to show this. The second part of the pamphlet takes up the use of warm or cold and moistened air for promoting germination, and of the use of hot dry air, in the malt kiln. By utilizing blowers to move this air, much quicker and better results may be obtained than by methods relying upon natural draft. It is also possible to run the plant to full capacity at all times of the year, and in all conditions of the weather.

INDEX TO TECHNICAL ARTICLES IN CURRENT PERIODICAL LITERATURE

Index is intended to cover the field of cal literature in a manner that will it of the greatest use to the greatest r—that is, it will endeavor to list all the s and comment of technical value ap-g in current periodicals. Its arrange-has been made with the view to its bility for a card-index, which engineers, cts and other technical men are grad-coming to consider as an indispensable t of their offices.

h item gives:

Title and author.

Name and date of publication.

An estimate of length of article.

A short descriptive note regarding the of the article—where considered neces-

Price at which we can supply current ar-

The Publishers do not carry copies of any of these articles in stock; but, if desired, will supply copies of the periodical containing the article at the prices mentioned. Any premium asked for out-of-date copies must be added to this price.

The principal journals in the various fields of technical work are shown in the accompanying list, and easily understood abbreviations of these names are used in the Index.

The Editor cordially invites criticisms and suggestions whereby the value and usefulness of the Index can be extended.

In order to comply with the many suggestions and requests of readers who desire to make practical use of this index, it will hereafter be printed on one side of the sheet only, to permit the clipping of any desired items.

LIST OF PERIODICALS INDEXED

JOURNALS, PROCEEDINGS AND TRANSACTIONS OF AMERICAN TECHNICAL SOCIETIES

l Am. Foundrymen's Assn.
l Assoc. Engineering Societies.
l Eng. Soc. of Western Pa.
l Franklin Institute.
l West. Society of Engineers.
dings Am. Soc. C. E.
dings Can. Soc. C. E.
dings Engineers' Club, Philadelphia.
Proceedings New York R. R. Club.
Proceedings Pacific Coast Ry. Club.
Proceedings St. Louis Ry. Club.
Proceedings U. S. Naval Institute.
Transactions Am. Inst. Electrical Engineers.
Transactions Am. Inst. Mining Engineers.
Transactions Am. Soc. Mechanical Engineers.

(Continued on second page following.)

AMERICAN AND CANADIAN PERIODICALS

ne Journal.
an Architect.
an Artisan.
an Builders' Review.—See Adv. oppo-
e.
an Carpenter & Builder.
an Engineer and R. R. Journal.
an Exporter.
an Gas Light Journal.
an Inventor.
an Journal of Science.
an Machinist.
an Shipbuilder.
ct & Engineer of California.
ctural Art.
ctural Record.
ctural Review.
cts' and Builders' Mag.
cture.
bile.
Maker.
World.

Am. Iron & Steel Assn.
of Dept. of Labor.
Univ. of Kansas.
Univ. of Wisconsin.
ia Journal of Technology.
n Architect.
n Cement & Concrete Review.
n Electrical News.
n Engineer.
n Machinery & Manufacturing News.
n Manufacturer.
n Mining Journal.
n Municipal Journal.—See Adv. oppo-
e.
ry and Building.
s Magazine.
s.

Age.
and Engineering News.
Era.
Station.
l Engineer.
orage and Ice Trade Journal.
rcial America.
ssed Air.—See Adv. opposite.
e.
e Age.
e Engineering.
tor.
r and Trade Reports.
Civil Engineer.
c Engineering.
ic Geology.
al Age.
al Review.
Journal.
Railway Review.—See Adv. opposite.
al World.
Traction Weekly.
hemical and Metallurgical Industry.—
Adv. opposite.
r.
ring-Contracting.—See Adv. opposite.
ring and Mining Journal.
ring Magazine.

Engineering News.—See Adv. opposite.
Engineering Record.
Engineer's Review.
Far Eastern Review.
Fire and Water Engineering.
Forestry and Irrigation.
Foundry.
Gas Engine.
Glass and Pottery World.
Hardware.
Heating and Ventilating Magazine.
Horseless Age.
Ice and Refrigeration.
Illuminating Engineer.
Implement Age.
Industrial Magazine.—See Adv. opposite.
Industrial World.
Inland Architect.
Insurance Engineering.
International Marine Engineering.
Iron Age.—See Adv. opposite.
Iron Trade Review.
Irrigation Age.
Journal of Electricity, Power and Gas.
Journal of U. S. Artillery.
Journal of Worcester Polytechnic Institute
Judicious Advertising.
Machinery.
Marine Review.
Metal Industry.
Metal Worker, Plumber and Steam Fitter.
Mines and Minerals.
Mining and Scientific Press.
Mining Reporter.
Mining World.
Modern Machinery.
Moody's Magazine.
Motor.
Motor Age.
Motor Boat.
Motor Car.
Motor Traffic.
Municipal Engineering.
Municipal Journal and Engineer.
Ores and Metals.—See Adv. opposite.
Paper Trade Journal.
Plumber's Trade Journal.
Popular Mechanics.
Popular Science Monthly.
Power.
Power and Transmission.
Power Wagon.
Practical Engineer.
Printers' Ink.
Progressive Age.
Railroad Gazette.
Railway Age.—See Adv. opposite.
Railway and Engineering Review.
Railway and Locomotive Engineering.
Railway and Marine World.
Railway Engineering.
Railway Master Mechanic.
Roadmaster and Foreman.—See Adv. opposite.
Rose Technic.
Scientific American.
Scientific American Supplement.
Selling Magazine.
Sibley Journal of Engineering.
Southern Machinery.
Stevens Institute Indicator.

Stone.
Street Railway Journal.
Technical World Magazine.
Technology Quarterly.
Textile Manufacturer's Journal.
Tradesman.
Waterproofing.
Western Electrician.
Wood Craft.
Wood Worker.

PRINCIPAL BRITISH PERIODICALS

Agricultural Chronicle. (m.) London.
Architect. (w.) London.
Architects' Magazine. (m.) London.
Architectural Review. (m.) London.
Autocar. (m.) London.
Automobile Journal. (m.) London.
Automotor Journal. (w.) London.
Board of Trade Journal. (w.) London.
British Architect. (m.) London.
British Clay Worker. (m.) London.
British Trade Review. (m.) London.
Builder. (w.) London.
Building Industries. (w.) Glasgow.
Civil Engineering. (w.) London.
Cold Storage. (m.) London.
Colliery Guardian. (w.) London.
Commercial Motor. (w.) London.
Concrete & Constr. Engg. (b-m.) London.
Contract Journal. (w.) London.
Electrical Engineer. (w.) London.
Electrical Engineering. (w.) London.
Electrical Magazine. (m.) London.
Electrical Progress. (m.) London.
Electrical Review. (w.) London.
Electrician. (w.) London.
Electricity. (w.) London.
Engineer. (w.) London.
Engineering. (w.) London.
Engineering Review. (m.) London.
Engineering Times. (w.) London.
Engineering World. (w.) London.
Engineers' Gazette. (m.) London.
English Mechanic. (w.) London.
Gas and Oil Power. (m.) London.
Gas Engineers' Magazine. (m.) London.
Implement and Machinery Rev. (m.) London.
India Rubber World. (m.) London.
Iron and Coal Trades Review. (w.) London.
Iron and Steel Trades Journal. (w.) London.
Ironmonger. (w.) London.
Ironmongers' Chronicle. (m.) London.
Journal of Gas Lighting. (w.) London.
Journal of Society of Arts. (w.) London.
Locomotive Magazine. (m.) London.
Marine Engineer. (m.) London.
Mariner. (m.) London.
Mechanical Engineer. (w.) Manchester.
Mechanical World. (w.) Manchester.
Mining Engineering. (m.) London.
Mining Journal. (w.) London.
Mining World. (w.) London.
Motor. (w.) London.
Motor Boat. (w.) London.
Motor Car Journal. (w.) London.
Motoring Illustrated. (m.) London.
Municipal Journal. (m.) London.
Nature. (w.) London.
Oil Trades Gazette. (m.) London.
Page's Weekly. (w.) London.
Paper Maker. (m.) London.
Paper Making. (m.) London.
Petroleum World. (m.) London.
Practical Engineer. (w.) London.
Public Works. (q.) London.
Quarry. (m.) London.
Railway Engineer. (m.) London.
Railway Gazette. (w.) London.
Railway Magazine. (m.) London.
Railway Times. (w.) London.
Science Abstracts. (m.) London.
Sells' Commercial Advertiser. (w.) Londo
Surveyor. (w.) London.
Textile Journal. (m.) London.
Timber Trades Journal. (m.) London.
Times Engineering Supplement. (w.) Lond
Tramway and Railway World. (m.) Londo
Water. (m.) London.

PRINCIPAL FRENCH, GERMAN AND OTHER FOREIGN PERIODICA

Annales des Ponts et Chaussées. (m.) Paris.
Beton und Eisen. (q.) Vienna.
Comptes Rendus de l'Acad. des Sciences. (w.) Paris.
Deutsche Bauzeitung. (b-w.) Berlin.
Dingler's Polytechnic Journal. (w.) Berlin.
Eisenbahntechnische Zeitschrift. (b-m.) Berlin.
Electricien. (w.) Paris.
Elektrochemische Zeitschrift. (m.) Berlin.
Elektrotechnik und Maschinenbau. (w.) Vienna.
Elektrotechnische Zeitschrift. (w.) Berlin.
Elettricità (w.) Milan
Génie Civil. (w.) Paris.
Gesundheits-Ingenieur. (s-m.) Munich.
Industrie Electrique. (s-m.) Paris
Ingenieria (s-m.) Buenos Aires
Ingenieur. (w.) Hague.
Métallurgie (w.) Paris.
Minero Mexicano. (w.) Mexico.
Mois Scientifique. (m.) Paris.
Revista d. Obras Pub. (w.) Madrid.
Revista Tech. Indus. (m.) Barcelona.
Revue de Mécanique. (m.) Paris.
Revue Gén. des Chemins de Fer. (m.) Pari
Revue Gén. des Sciences. (w.) Paris.
Revue Industrielle. (w.) Paris
Revue Technique. (b-m.) Paris.
Revista Marittima. (m.) Rome.
Schiffbau. (s-m.) Berlin.
Schweizerische Bauzeitung. (w.) Zurich.
Stahl und Eisen. (w.) Düsseldorf.
Technique Sanitaire. (m.) Paris.
Zeitschrift f. d. Gesamte Turbinenwesen. (Munich.
Zeitschrift d. Oest. Ing. und Arch. Ver. (Vienna.
Zeitschrift d. Ver Deutscher Ing. (w.) Be
Zeitschrift für Elektrochemie. (w.) Halle
Zentralblatt d. Bauverwaltung. (s-w.) Be

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INDEX TO ARTICLES

AUTOMOBILES AND AERIAL NAVIGATION

Aerial Navigation.

New European Flying Machines. Sc Am—Oct 26, 07. 7 figs. 3000 w. 20c. Illustrated description of a number of newly-tried machines.

The First British Military Airship. Harold J. Sheepstone. Sc Am—Oct 5, 07. 2 figs. 2100 w. 20c.

The Gammeter Orthopeter—A Beating-Wing Flying Machine. H. C. Gammeter. Sc Am—Oct 12, 07. 1100 w. 20c.

Automobile Design.

Future Motor Car Construction. M. C. Krarup. Ir Age—Oct 10, '07. 6000 w. 20c. Analyzes present features and suggests changes.

The Design of an Automobile Steering Gear. E. W. Graham. Am Mach—Oct 3, 07. 11 figs. 3200 w. 20c.

Carburetter.

The Carburetter and Its Functions. Charles E. Duryea. Automobile—Oct 3, 07. 1 fig. 6200 w. 20c. Paper read before the Society of Automobile Engineers, Buffalo, N. Y. July, 1907.

Materials.

Malleable Castings for Motor Cars.—Ill. P. I. Giron. Mech Wld—Oct. 18, 07. 3 figs. 1300 w. 20c.

Testing and Efficiency.

Effect of Size on the Thermal Efficiency of Motors. H. L. Callendar. Mech Wld—Oct. 18, 07. 1900 w. 20c.

Methods of Testing Automobile Engines for Efficiency. Z V D I—Oct. 5, 07. 13 figs. 4000 w. 60c.

CIVIL ENGINEERING

BRIDGES.

Abutment, Reinforced-Concrete.

Discussion, Design and Specifications for A Reinforced-Concrete Bridge Abutment. T. M. Fyshe. Proc Can Soc C. E. 9000 w. 80c. Paper read before the Society, Oct. 18, 07.

Arch.

The Construction of the 175th Street Arch, New York City. Eng Rec—Oct. 5, 07. 2 figs. 1100 w. 20c.

Bascule Bridge.

Page Bascule Bridge Over the Chicago River. Ry & Eng Rev—Oct. 26, 07. 4 figs. 1100 w. 20c. Describes a new single-leaf, double-track bascule bridge.

Brick-Arch Floors.

The Stability of Brick-Arch Floors in Metallic Bridges. P. Caufourier. Génie Civil—Oct. 12, 07. 8 figs. 3000 w. 60c.

Bridge Pedestal.

The Manhattan Bridge Pedestal. Eng Rec—Oct. 19, 07. 4 figs. 3700 w. 20c.

Brooklyn Bridge Anchorage.

Concrete Anchorage in the Brooklyn Bridge. Charles M. Ripley. Cem Age—Oct., 07. 2 figs. 2900 w. 20c. Gives a comparison of the amount of masonry with that used in other large structures, together with details of construction and methods of handling materials and particulars concerning a modern contractor's plant.

Design.

A Few Notes on Riveting. E. O. Ritter. Arch & Engr of Cal—Oct., 07. 2 figs. 1000 w. 60c.

Continuous Girders. Engr. (Lond)—Sept. 27, 07. 5 figs. 3500 w. 40c. Discusses the continuous girders which result from strengthening existing bridges by intermediate piers.

Imperfect Butt-Joints in Columus, and Stresses in Lattice-Bars. Henry S. Prichard. Eng. News—Oct. 3, 07. 5 figs. 7200 w. 20c. A mathematical consideration of several problems in bridge design.

Erection.

Erecting Six-Track Plate Girder Bridges With a Derrick Car. Eng Rec—Oct. 19, 07. 5 figs. 2500 w. 20c. Describes methods used on the Harlem Branch of the N. Y., N. H. & H. R. R.

Notes on the Erection of Bridges. Ry Engr—Oct., 07. 2 figs. 3100 w. 40c. VI.—Rolling out continuous girders; continuous girders in general.

Quebec Bridge.

Long Struts. Engr (Lond)—Oct. 18, 07. 1200 w. 20c. Editorial criticizing the design of the compression members in the Quebec Bridge.

Theodore Cooper on the Quebec Bridge and Its Failure. Eng News—Oct. 31, 07. 10,000 w. 20c.

The Compression Members of the Quebec Bridge. Eng News—Oct. 3, 07. 1 fig. 3700 w. 20c.

The Quebec Bridge. Frank W. Skinner. Engg—Sept. 27, 07. 4 figs. 4300 w. 40c. Oct. 4. 9 figs. 8700 w. Oct 11. 4300 w. Oct. 18. 4100 w. Each 40c. Continuation of serial giving details of members and connections on the erection of the cantilever arms.

The Quebec Bridge Wreck. Eng News—Oct. 10, 07. 21 figs. 2700 w. 20c. Explanatory text to accompany large-scale half-tone views showing this huge heap of wrecked steel work from one end to another.

The Wreck of the Quebec Bridge. E. R. Kinloch. Indus Mag—Oct., 07. 6 figs. 3800 w. 20c.

Viaducts.

Ferro-Concrete Viaduct for the Cala Mineral Railway, Seville. Mateo Clark. Engg—Oct. 18, 07. 10 figs. 2800 w. 40c.

The Erection of the Moodna Creek Viaduct. Eng Rec—Oct. 26, 07. 3 figs. 2400 w.

The Nelson Street Viaduct at Atlanta. Eng Rec—Oct. 12, 07. 3 figs. 1500 w. 20c. Describes a reinforced-concrete structure 479 ft. long, made up of ten flat-arch spans.

EARTHWORK, ROCK EXCAVATION, ETC.

Excavation, Cost of.

Cost of Excavating Earth. Conc Engg—Oct., 07. 700 w. 20c.

The Cost of Hydraulic Sluicing a Highway Embankment. Engg-Contr—Oct. 9, 07. 1400 w. 20c.

Methods and Cost of Moving Earth in the Fresno Scrapers in Arizona and the Cost of Trimming Slopes. Engg-Contr—Oct. 2, 07. 2 figs. 1700 w. 20c.

Drilling.

Charts for Recording Drill Holes and Daily Report Card Showing Explosives Used. Engr-Contr—Oct. 23, 07. 4 figs. 1700 w. 20c.

Cost of Rock Drilling in Swedish Mines. Comp. Air—Oct., 07. 700 w. 20c. From "Teknish Tidskrift," Stockholm.

The Cost of Hand Drilling and Sharpening Steel, and Burning Charcoal. Engg-Contr—Oct. 2, 07. 1 fig. 1100 w. 20c.

Fills, Aerial Cableway and Trestle.

Comparative Cost of Making a Fill: Trestle vs. Aerial Cableway. J. D. Mooney. Indus Mag—Oct., 07. 3 figs. 1600 w. 20c.

Comparative Cost of Trestle and Cableway Railroad Fills. Conc Engg—Oct., 07. 900 w. 20c.

Cost of An Aerial Cable Bridge Used in Making a Deep Fill With Dump Cars. J. D. Mooney. Engg-Contr—Oct. 2, 07. 1 fig. 1100 w. 20c.

Fills Made From Cars Running on a Suspended Cableway. Eng News—Oct. 10, 07. 4 figs. 2300 w. 20c.

Trenching.

Backfilling Trenches. Geo. C. Warren. Eng News—Oct. 10, 07. 2700 w. 20c. From a paper read at the annual meeting of the American Society of Municipal Improvements, Detroit, Mich. Oct. 1.

Excavating with Potter Trenching Machine for 16-Ft. Sewer, with Cost Data. Engg-Contr—Oct. 9, 07. 2 figs. 1200 w. 20c.

ENGINEERING CONSTRUCTION.

Buildings.

An Umbrella Shed for Market Storage. Eng Rec—Oct. 5, 07. 1 fig. 1100 w. 20c.

Concrete Buildings. Conc Engg—Oct., 07. 3500 w. 20c. Report of committee at the convention of the Association of Railway Superintendents of Bridges and Buildings, Milwaukee, Wis. Oct. 15-17.

Cost of Concrete for Factory Foundation. Conc Engg—Oct., 07. 200 w. 20c.

Fireproof Construction.—I. M. M. Sloan. Arch & Bldrs Mag—Oct., 07. 1 fig. 3200 w. 40c.

Method and Cost of Building a Reinforced-Concrete Car Barn. Engg-Contr—Oct. 23, 07. 4 figs. 1800 w. 20c.

Method and Cost of Constructing Reinforced Kiln House of Separately Molded Members, Edison Portland Cement Co. Engg-Contr—Oct. 2, 07. 7 figs. 3600 w. 20c.

Methods and Cost of Erecting a 6-Story Reinforced Concrete Building. Engg-Contr—Oct. 9, 07. 3 figs. 2400 w. 20c.

Rapid Factory Construction. C. M. Ripley. Ir Age—Oct. 10, 07. 900 w. 20c. Gives account of a factory building erected at Newark, N. J., in twenty-nine days.

Temporary Elevators for the Erection of the Singer Building Tower. Eng. Rec—Oct. 12, 07. 5 figs. 2400 w. 20c.

The Contractor's Plant for a Concrete Warehouse. A. K. Reading. Indus Mag—Oct., 07. 6 figs. 2700 w. 20c.

The Cost of Six Ice Houses. Engg-Contr—Oct. 9, 07. 3200 w. 20c.

Underpinning a 400-ton Pier. Eng Rec—Oct. 19, 07. 3 figs. 800 w. 20c. Describes methods used in the course of work in the Philadelphia subway.

Chimneys, Reinforced Concrete.

The Design of Reinforced Concrete Chimneys. Conc Engg—Oct. 07. 4 figs. 2900 w. 20 c.

Conduits.

A Method of Laying Vitrified Conduits for Electrical Cables, and a Collapsible Core for Forming Conduits in Concrete Without the Use of Vitrified Ducts. F. Lavis. Eng News—Oct. 3, 07. 7 figs. 2700 w. 20c.

Fundamental Formulas for the Calculation of Water Pipes and Conduits. E. Sonne. Z V D I—Oct. 12, 07. 2 figs. 7000 w. 60c.

Dams.

A Collapsible Steel Dam Crest, Bear River, Near Garland, Utah. J. C. Wheelon. Eng News—Oct. 3, 07. 4 figs. 2000 w. 20c.

Crocker's Reef Dam Across the Hudson at Ft. Edward. Eng Rec—Oct. 5, 07. 4 figs. 2100 w. 20c.

Hydraulic Excavation and Dam Building at the Croton and Lyons Dams in Michigan. Wm. G. Fargo. Eng News—Oct. 24, 07. 7 figs. 5400 w. 20c.

Masonry Dams. Thomas G. Bocking. Engr (Lond)—Sept. 27, 07. 6 figs. 2200 w. 40c. Discusses a formula for ascertaining the "nucleus" of a dam section and applies it to a number of large masonry dams.

Docks and Piers.

A Concrete Pier at Montreal. Can Engr—Oct. 4, 07. 2 figs. 1700 w. 20c. Describes the 1,000-ft. "Tarte" high-level pier recently constructed.

New Graving Docks and Shipyard on the River Tees. Engr (Lond)—Oct. 18, 07. 6 figs. 1900 w. 40c.

The First Lake Dock of Steel. Dwight E. Woodbridge. Ir Age—Oct. 3, 07. 3 figs. 2400 w. 20c. Gives details of the structure to be built at Two Harbors, Minn.

Reinforced-Concrete Construction.

Concrete Construction; Its Regulation and Control. E. S. Larned. Ir Age—Oct. 10, 07. 4800 w. 20c. Read before the Association of American Portland Cement Manufacturers, Atlantic City, N. J. Sept. 11.

How to Prevent Failure in Concrete Construction. Dr. W. Michaelis, Jr. Sc Am Sup—Oct. 12, 07. 6100 w. 20c. Gives an expert analysis of an important problem. Abstracted from a paper read before the Western Society of Engineers.

Sound Concrete Construction. J. T. Noble Anderson. Engr (Lond)—Oct. 4, 07. 6000 w. Oct. 11. 3300 w. Oct. 18. 4100 w. Each 40c. Embodies gleanings from an experience of 20 years in concrete work, plain and reinforced, taking up the questions of ingredients, false work, finish, etc.

The Forms for Concrete Construction. A. D. Williams, Jr. Conc Engg—Oct., 07. 6 figs. 2400 w. 20c.

Reservoir Repairs.

Repairing a Remarkable Leak in a Reservoir Embankment at Providence, R. I. Eng News—Oct. 17, 07. 1 fig. 1500 w. 20c.

Retaining Wall.

Cost of Concrete in Retaining Wall at Allegheny, Pa. Conc Engg—Oct., 07. 1400 w. 20c.

Steel Tank Design.

The Design of Rectangular Steel Tanks. Ernest G. Beck. Mech Wld—Sept. 27, 07. 10 figs. 3700 w. 20c.

Tetrahedral Cell Tower.

The Outlook Tower of Beinn Bhreagh, the First Iron Structure Built of Tetrahedral Cells. T. W. Baldwin. Sc Am—Oct. 5, 07. 7 figs. 1800 w. 20c.

Tunnels.

A Machine for Tunneling in Shale. Eng Rec—Oct. 19, 07. 1600 w. 20c.

An Unusual Plant for Constructing a Submarine Tunnel at Chicago. Eng Rec—Oct. 26, 07. 7 figs. 4300 w. 20c.

Carrying a Steel Water Main Under a Railway. Eng Rec—Oct. 5, 07. 4 figs. 700 w. 20c.

Lining a Tunnel With Concrete. Eng Rec—Oct. 12, 07. 5 figs. 2800 w. 20c. Describes work on a 2,200-ft. single-trench tunnel in So. Indiana.

Some Recent Investigations in the Hygiene of Sub-Aqueous and Subterranean Work. J. S. Haldane. Min Jl—Oct. 5, 07. 1000 w. 40c. Abstract of an address delivered Sept. 26 at the general meeting of the International Congress of Hygiene at Berlin.

The Detroit River Tunnel Caissons. Eng Rec—Oct. 12, 07. 1 fig. 600 w. 20c.

The Market Street Subway, Philadelphia. Eng Rec—Oct. 12, 07. 9 figs. 3100 w. 20c.

The Reconstruction of the Eighth Street Tunnel, Kansas City. Eng Rec—Oct. 5, 07. 1 fig. 1700 w. 20c.

The Tunnels of the Michigan Central Railroad Under the Detroit River. Ir Tr Rev—Oct. 17, 07. 6 figs. 2200 w. 20c. Gives the details of construction, the plan and profile of the tunnel, together with sections of the completed tunnel at various stations.

Ventilation of the Battery Tunnels of the New York Subway Extension to Brooklyn. Eng Rec—Oct. 5, 07. 3 figs. 3600 w. 20c.

Waterproofing.

Some Difficulties in the Waterproofing of the Manhattan Subway Terminal of the Williamsburg Bridge. B. J. Feldman. Waterproofing—Sept., 07. 1 fig. 3100 w. 20c.

The Causes of Dampness in Houses. Dr. Geo. M. Price. Waterproofing—Sept., 07. 3200 w. 20c.

Waterproofing by the Addition of Compounds to Cement. An Open Discussion. Waterproofing—Sept., 07. 600 w. 20c.

MATERIALS.

Cement and Concrete.

Cement Production in the United States. Eng News—Oct. 17, 07. 1300 w. 20c. Gives data from the regular annual report issued by the U. S. Geological Survey.

The Effect of Increasing the Aggregate Content on the Compressive Strength of Concrete. Herr Brabandt. Zeit d Bau—Oct. 9, 07. 1 fig. 2500 w. 40c.

Suggestions for the Manufacture and Use of Concrete Blocks. Engg-Contr—Oct. 16, 07. 1 fig. 3500 w. 20c. Extracts from a

paper read before the Assn. of Am. Portland Cement Manufacturers, Sept. 11, 07, by E. S. Larned.

Cement Plants.

Electric Motors for Cement Mills. R. B. Williamson. Eng Rec—Oct. 5, 07. 1 fig. 1800 w. 20c.

Municipal Cement Plant for the Los Angeles Aqueduct. Eng News—Oct. 3, 07. 1400 w. 20c.

Protective Covering.

A New Blue-Black Iron Paint as a Protective Covering. F. J. R. Carulla. Ir & Cl Tr Rev—Sept. 27, 07. 1000 w. 40c. Paper read at the Vienna meeting of the Iron & Steel Inst. Sept. 23-24.

Testing Laboratory.

Investigation of Structural Materials by U. S. Geological Survey. Cem Age—Oct., 07. 6 figs. 2900 w. 20c. By Richard L. Humphrey, Engineer in Charge of Structural Materials Division and issued by the Technological Branch of the U. S. Geological Survey.

Structural Materials Testing Laboratories of the United States Geological Survey, St. Louis, Missouri. Herbert M. Wilson. Eng News—Oct. 17, 07. 3 figs. 3300 w. 20c.

RIVERS, CANALS, HARBORS.

Dredges, Pipe Connection for.

A New Flexible Connection for Suction Pipes of Dredges. Eng Rec—Oct. 19, 07. 1 fig. 1400 w. 20c.

Foreshore Protection.

Ferro-Concrete Groynes Near Brighton. Engr (Lond)—Sept. 27, 07. 6 figs. 1200 w. 20c. Describes a method of foreshore protection used to prevent the erosion of high chalk cliffs.

Harbor Improvement.

Harbor Work at Huron, Ohio. Eng Rec—Oct. 26, 07. 7 figs. 1800 w. 20c.

The Development of the Port of Havre. Engr (Lond)—Oct. 11, 07. 5 figs. 3000 w. 40c.

Irrigation.

The Greatest Need of Arid America. Samuel Fortier. Ir Age—Oct., 07. 1 fig. 4700 w. 40c.

West Neebish Channel.

The Excavation of the West Neebish Channel in the St. Mary's River, Michigan. Eng News—Oct. 10, 07. 8 figs. 5300 w. 20c. Describes methods used in this improvement to navigation on the Great Lakes.

SURVEYING, MENSURATION.

Accuracy in Calculations.

The Elements of Accuracy and Precision in Engineering Calculations. Robert J. McNitt. Sibley Jl Engg—Oct., 07. 2800 w. 40c.

Planimeter.

The Planimeter. Frank J. Gray. Surv—Sept. 27, 07. 7 figs. 2100 w. 40c. Concluded.

Tripod for Surveying in Brush.

A Tripod Used for Surveying in Thick Scrub. John L. Hildreth. Eng News—Oct. 10, 07. 2 figs. 1000 w. 20c. Describes a tripod and platform used in an extensive stadia survey through thick scrub, oak and pine on Long Island.

Triangulation and Traverse Work.

Triangulation and Traverse Work in the Bronx, New York City. Eng Rec—Oct. 5, 07. 2 figs. 3000 w. 20c.

ECONOMICS

Apprentice System.

A Rational Apprentice System. New York Central Lines. Am Engr & R R Jl—Oct., 07. 30 figs. 14,200 w. 40c. Ill. The apprentice courses or schedules.

Cost Accounting.

Cost Determining. W. R. Koller. Ir Age—Oct. 10, 07. 7 figs. 2000 w. 20c. Describes system for ascertaining manufacturing costs where piece-work is done.

Piece-Work Rates and Premiums. W. R. Rosch. Am Mach—Oct. [illegible] 07. [illegible] w. 20c.

Depreciation.

Depreciation. A. C. Humphreys. Am Gas [illegible] Oct. [illegible] w. [illegible] Paper read before the American Gas [illegible] Washington, Oct. [illegible]

Engineering Education.

[illegible] H. Norris. St Ry Jl—Oct. 19, 07. 1800 w. 20c. Paper presented at the Atlantic City Convention of the American Street & Interurban Railway Association, Oct. 16.

The Training of Engineers on the "Sandwich" System. L. D. Coulesant. Engg—Oct. 11, 07. 2800 w. 40c. Describes the apprentice-studentship scheme of the Sunderland Technical College.

Factory Management.

Profit Making in Shop and Factory Management. Charles U. Carpenter. Eng Mag—Nov., 07. 3700 w. 40c. IX. The Upbuilding of a Selling Organization.

Patents.

Establishing the Right to a Patent on the [illegible] John E. Brady. El W[illegible] Oct. [illegible] 07. [illegible] w. 20c.

[illegible] Patented Articles. Irving D. N[illegible]—Oct. 3, 07. 1900 w. 20c.

ELECTRICAL ENGINEERING

ELECTROCHEMISTRY.

The Electrolysis of Fused Salts. Engg—Oct. 18, 07. 1100 w. 40c.

ELECTROPHYSICS.

A. C. Armature Reaction.

A Method of Studying Armature Reaction in Alternating Current Dynamos. F. C. Caldwell. Sibley Jl of Engg—Oct., 07. 3 figs. 1400 w. 40c.

Condenser Losses.

Losses in Condensers with Solid Dielectrics and Their Damping Action on High-Frequency Circuits. W. Hahnemann and L. Adelmann. Elek Zeit—Oct. 10, 07. 6 figs. 3000 w. 40c.

Induction Coil.

The Secondary Current of the Induction Coil. H. Clyde Snook. Jl of Franklin Inst. —Oct., 07. 6 figs. 3000 w. $1.00. Discusses the currents flowing in the secondary of an induction coil as observed by the means of a Duddell high-frequency oscillograph.

Losses in Asynchronous Motors.

The Separation of the Losses in Asynchronous Motors. W. Linke. Elek Zeit—Oct. 3, 07. 18 figs. 4500 w. 40c.

Synchronous Motor Losses.

Excitation Characteristics of the Synchronous Motor. A. S. Langsdorf. El Wld —Oct. 19, 07. 3 figs. 1900 w. 20c.

GENERATORS, MOTORS, TRANSFORMERS.

D.-C. Generators.

Direct-Current Turbo-Generators. H. D. C. Beyer. Elek u Masch—Sept. 28, 07. 10 figs. 5500 w. Oct 6. 5 figs. 3500 w. Each, 60c.

Stationary Apparatus for Dividing the Tension of a D.-C. Dynamo for Supplying a Three-Wire Network. E. J. Brunswick. L'Industrie Elec—Sept. 25, 07. 11 figs. 4000 w. 60c.

Three-Wire D.-C. Generators. B. T. McCormick. Can El News—Oct., 07. 2 figs. 1300 w. 20c. Describes briefly the principles of operation of three-wire generators which are the outgrowth of the Edison three-wire system. Paper read at the annual convention of the Canadian Electrical Association, Montreal, Sept. 11.

D.-C. Motors.

A New System of Automatic Short-Circuit Braking for Motors. M. Kallmann. Elek Zeit—Sept. 26, 07. 11 figs. 4000 w. 40c.

How to Select Direct-Current Electric Motors for Different Kinds of Service. C. C. Stutz. Am Mach Oct. 3, 07. 400 w. 20c.

Interpoles, Effects of.

The Effects of Interpoles on the Working of Generators and Motors. H. Zipp. Elek u Masch—Sept. 8, 07. 15 figs. 500 w. 60c.

Transformers.

Parallel Connections for Transformers. George Stern. Elek Zeit—Oct. 10, 07. 6 figs. 2000 w. 40c.

Three-Phase Two-Phase Transformation. Edmund C. Stone. El Jl—Oct., 07. 2 figs. 1500 w. 20c.

Unbalanced Loads in Two-Phase to Three-Phase Transformation. Bernh. F. Jakobsen. El Wld—Oct. 12, 07. 5 figs. 1800 w. 20c.

LIGHTING.

Illumination from Inclined Sources.

Calculation of Illumination from Inclined Light Sources. J. S. Codman. El Rev—Oct. 5, 07. 4 figs. 1200 w. 20c.

Light, Mechanical Equivalent of.

The Mechanical Equivalent of Light. Engg —Oct. 18, 07. 2100 w. 40c.

Mercury-Vapor Lamp.

A New Mercury-Vapor Lamp in Competition with Arc Lamps. El Wld—Oct. 19, 07. 4 figs. 3300 w. 20c. Describes lamp having a tube of fused quartz instead of glass, so that it stands very much higher temperatures.

Nernst Lamp.

The Value of the Nernst Lamp to the Central Station. A. E. Fleming. Cent Stat—Oct., 07. 3000 w. 20c.

Tantalum.

Tantalum. Sc Am Sup—Oct. 5, 07. 2400 w. 20c. Abstract from an article in "Revue Scientifique," describing the properties of this metal.

PLANTS AND CENTRAL STATIONS.

A. C. Systems, Difficulties in Operating.

Trials of the Operating Man. M. A. Sammett. Can El News—Oct., 07. 17 figs. 6200 w. 20c. Discusses difficulties met with in operating alternating current systems. Paper read at the Annual Convention of the Canadian Electrical Association, Montreal, Sept., 1907.

Construction.

Modern Power Station and Electrical Construction. W. A. Haller. Jl of Assoc. Engg Socs—Sept., 07. 7 figs. 7000 w. 60c. Paper read before the Louisiana Engineering Society at its meeting, May 13, 07.

Electrical Development.

The Possibilities of Electrical Development. R. Borlase Matthews. El Rev (Lond)—Oct. 18, 07. 3600 w. 40c. Abstract of a paper read before the Birmingham and District Electric Club, October 10.

Manchester (Eng.) Industrial Supply.

The Supply of Electrical Energy for Industrial Purposes by the Manchester (England) Corporation. El Wld—Oct. 26, 07. 8 figs. 2400 w. 20c.

Public Lighting.

Public Lighting Service, Corporate and Municipal. Judson H. Houghton. Eng Mag—Nov., 07. 2 figs. 3200 w. 40c. Gives the practical data concerning the cost and the working of small and medium plants, with comments upon privately and municipally operated lighting stations.

TELEGRAPHY AND TELEPHONY.

Sag of Telegraph Lines.

Graphic Determination of the Sag of Telegraph Lines. G. Nicolaus. Elek Zeit—Sept. 12, 07. 4 figs. 4000 w. Sept. 19. 12 figs. 5000 w. 40c.

Telephone Cable Work.

Features of Work in a Well-Systemized Cable Department. O. R. Barnes. Am Tel Jl—Oct. 12, 07. 4 figs. 3600 w. 20c.

Telephone Line on Poles of a 72,000-Volt System.

Successful Operation of the Telephone Line on 72,000-Volt Transmission Poles. R. D. Lillie. Am Tel Jl—Oct. 12, 07. 4 figs. 2400 w. 20c.

Toll Lines.

The Maintenance of Toll Lines and Operation of Composite Circuits. N. C. Kissell. Am Tel Jl—Oct. 12, 07. 5 figs. 4200 w. 20c.

TESTS AND MEASUREMENTS.

Armature and Field Resistances.

The "Drop" Method of Testing Armature and Field-winding Resistance. E. S. Lincoln. Power—Nov., 07. 1 fig. 1800 w. 40c.

Electrical Porcelain.

The Design and Testing of Electrical Porcelain. Dean Harvey. El Jl—Oct., 07. 11 figs. 4000 w. 20c.

Insulation Resistance.

A Method of Testing D. C. Networks for Insulation Resistance During Working. Daniel Shirt. El Rev (Lond)—Oct. 11, 07. 2 figs. 900 w. 40c.

Central Station Light, Heat and Power Principles. Newton Harrison. Cen Sta.—Oct., 07. 4 figs. 2800 w. 20c. Gives methods for measuring the resistance of insulation.

Iron Losses in A. C. Apparatus.

Measurement of Iron Losses in Alternating Current Apparatus. J. Sahulka. Elek Zeit—Oct. 10, 07. 5 figs. 3000 w. 40c.

Resistance Coils.

Resistance Coils and Comparisons. C. V. Drysdale. Elec'n—Sept. 27, 07. 12 figs. 2500 w. Oct. 4. 4 figs. 3700 w. Each 40c. Gives a survey of resistance coils showing their evolution up to the present time and the methods used in accurate measurements of resistance; also results of tests on a number of resistance alloys. Paper read before the British Association at Leicester, Aug. 19, 07.

Watt-Meters.

Metering Commercial Electrical Currents. H. Miller. El Jl—Oct., 07. 10 figs. 6000 w. 20c. Describes several types of integrating watt-meters and methods of operating and testing.

TRANSMISSION, DISTRIBUTION, CONTROL.

A. C. Cable Losses.

The Losses in Heavy Alternating Current Cables. El Rev (Lond)—Oct. 11, 07. 4 figs. 1100 w. 40c. Describes some interesting experiments on the increased resistance offered to alternating currents by cables of large section.

Aluminum Conductors.

The Use of Aluminum as an Electrical Conductor. H. W. Buck. Engrs Rev—Oct., 07. 900 w. 20c.

D. C. Transmission.

The Thury Direct-Current Transmission System. D. Kos. El Wld—Oct. 26, 07. 8 figs. 6500 w. 20c. Discusses its principal features as developed to date and its possibilities.

Distribution Systems.

System at Minneapolis for Distributing the Energy Transmitted from Taylor's Falls. El Wld—Oct. 5, 07. 9 figs. 2500 w. 20c.

A Graphical Method of Determining the Voltage Drop in Power Distribution Systems. T. L. Kolkin. El Rev (Lond)—Oct. 11, 07. 7 figs. 2000 w. 40c.

Grounded Neutrals.

Earthing the Neutral Point. E. V. Shaw. El Rev (Lond)—Oct. 18, 07. 3 figs. 1500 w. 40c.

The Grounded Neutral with and Without Series Resistance, in High-Tension Systems. Paul M. Lincoln. Proc Am Inst El Engrs—Sept., 07. 1 fig. 5000 w. 60c. Read before the Am Inst El Engrs, New York, Oct. 11.

Line Constants.

Line Constants and Abnormal Voltages and Currents in High-Potential Transmission. Ernst J. Berg. Proc Am Inst. El Engrs—Sept., 07. 6 figs. 7100 w. 60c. Read before the Schenectady Branch of the Am Inst El Engrs, Jan. 31.

Line Construction.

Recent Improvements in Catenary Line Construction and Methods of Installation. St Ry Jl—Oct. 26, 07. 3 figs. 4400 w. 20c.

Switchboards.

Switchboards for Small Stations. E. T. Mug. El Rev—Oct. 5, 07. 9 figs. 1700 w. 20c.

Switchboard Wire Protection. T. W. Poppe. El Wld—Oct. 5, 07. 3 figs. 800 w. 20c.

Transmission Plant.

The Transmission Plant of the Niagara, Lockport and Ontario Power Company. Ralph D. Mershon. Proc Am Inst El Engrs —Sept., 07. 38 figs. 7000 w. 60c. A paper presented at the 24th annual convention of the Am Inst El Engrs, Niagara Falls, June 26.

Transformer Wiring.

Wiring and Connections for Constant Potential Transformers. Geo. A. Burnham. El Wld—Oct. 5, 07. 20 figs. 2000 w. 20c.

MISCELLANEOUS.

Picture Telegraphy.

Recent Development in Picture Telegraphy. Dr. Alfred Gradenwitz. Sc Am—Oct. 26, 07. 8 figs. 1800 w. 20c.

INDUSTRIAL TECHNOLOGY

Acetylene.

Acetylene: Its Adaptability to Various Uses. Sir Charles S. Forbes. Pub Wks—Oct.-Dec., 07. 18 figs. 5500 w. 60c.

Brick Manufacture.

A Novel Method of Ascertaining Fuel Consumption. Brit Clayworker—Oct., 07. 4 figs. 800 w. 40c.

The Mechanical Treatment of Limey Clays. Brit Clayworker—Oct., 07. 2700 w. 40c.

Firing a Continuous Kiln. XI. Brit Clayworker—Oct., 07. 5 figs. 5900 w. 40c.

Explosives.

Modern Explosives. H. Schmerber. Génie Civil—Sept. 21, 07. 2800 w. 60c. Continued.

Gas Manufacture.

Repairing the Cup of a Two-Lift 500,000 Cubic-Foot Gas Holder. Geo S. Colquhoun. Jl of El Power & Gas—Oct. 5, 07. 1 fig. 1500 w. 20c. Paper read before the Pacific Coast Gas Assn, Santa Cruz, Cal., Sept. 17, 1907.

Studies in the Manufacture of Coal Gas. Prof. Alfred H. White and Fred E. Park. Am. Gas Lt Jl—Oct. 7, 07. 6 figs. 5500 w. 20c. Paper prepared for the fifteenth meeting of the Michigan Gas Association. Describes experimental plant and its operation; influence of size of charge on products of destructive distillation; products of distillation; work of the condenser; work of the tar separator; the elimination of naphthaline; work of the tar washer and the scrubber.

Sulphur and Oil Gas. P. W. Prutzman. Prog Age—Oct. 15, 07. 2200 w. 20c. Read before the Pacific Coast Gas Assn, Sept. 17, 1907.

Lampblack.

Lampblack. Am Gas Lt Jl—Oct. 7, 07. 2700 w. 20c. A composite paper by several members, prepared for the fifteenth meeting of the Pacific Coast Gas Assn.

Producer Gas in Chemical Industries.

Use of Producer Gas in Chemical Industries. Oskar Nagel. Min Rep—Oct. 10, 07. 2 figs. 2000 w. 20c. From Electrochem & Met Ind, Sept., 1907.

Recovery of Tin from Iron Scrap.

Extraction of Tin from Iron Scrap. C. Powell Karr. Met Wkr—Oct., 07. 2400 w. 20c.

Rubber Goods, Manufacture of.

Manufacture of Mechanical Rubber Goods. Sc Am—Oct. 5, 07. 8 figs. 3300 w. 20c. Illustrated description of the manufacture of rubber hose, packing, tiling, belts, etc.

Zinc Pigments, Manufacture of.

Manufacture of Zinc Pigments. Mines & Min—Sept., 07. 2 figs. 2300 w. 40c. Describes process used at Coffeyville, Kansas, for making zinc oxide and leaded zinc

MARINE ENGINEERING

Hydro-Plane Boat.

The Crocco and Ricaldoni Hydro-Plane Boat. Engg Oct. 4, 07. 5 figs. 800 w. 40c.

Launching, Disaster at.

The Disaster at Riva Trigoso, Italy. Engg Oct 11 07. 2 figs. 900 w. 40c. Describes the heeling over and sinking of the "Principessa Jolanda" at its launching.

"Lusitania."

The Cunard Turbine Liner "Lusitania." L. Piaud. Génie Civil—Sept. 21, 07. 20 figs. [illegible] w. 60c. First of a series of descriptive articles.

Navigation.

Navigation by Celestial Observation—II. Stephen P. M. Tasker. Int Mar Engg—Nov., 07. 8 figs. 3200 w. 40c.

New Steamships.

The Steamships Delaware and Pawnee. Charles S. Linch. Int Mar Engg—Nov., 07. 5 figs. 4000 w. 40c.

Shaft Brackets.

Size of Shaft Brackets. Mariner & Engg Rec—Oct. 15, 07. 1000 w. 40c.

Steel Colliers.

New Steel Steam Colliers. Int Mar Engg —Nov., 07. 4 figs. 2000 w. 40c. Describes vessels intended for the coal trade between Boston and the South.

Superheating in Marine Practice.

Superheating in Marine Practice. Mech Engr—Sept. 28, 07. 4 figs. 1500 w. Oct. 5. 2 figs. 900 w. Each 40c.

R. R. Transfer Boat.

The Steamer Maryland. Int Mar Engg—Nov., 07. 9 figs. 2400 w. 40c. Describes a recently completed twin-screw steel transfer boat for the N. Y. P. & N. R. R. Co. to run between Cape Charles and Norfolk.

Vessel of the Future.

The Vessel of the Future. Arthur E. Liddell. Int Mar Engg—Nov., 07. 3700 w. 40c.

MECHANICAL ENGINEERING

AIR MACHINERY.

Compressors.

Turbo-Compressors from a Thermodynamic Standpoint. W. Schüle. Z V D I—Oct. 18, 07. 7 figs. 3000 w. 60c.

1200-Horse Power Air Compressor. Engr (Lond)—Oct. 11, 07. 7 figs. 1800 w. 40c. Describes an English colliery plant in which the piston speed and output are considerably in excess of those usual in air compressor practice.

Pneumatic Tools.

Pneumatic Tools for Boiler Shops—I. Charles Dougherty. Boiler Maker—Nov., 07. 12 figs. 2400 w. 20c. Describes important points on the design, operation and care of pneumatic drills, hammers and hoists.

FOUNDING.

Casting Under Pressure.

Casting Metals Under Pressure. H. Martin. Castings—Oct., 07. 1 fig. 900 w. 20c.

Cupola.

The Cupola. Castings—Oct., 07. 2 figs. 3600 w. 20c. First of a series of articles on mixtures, melting operations, etc.

Dust Removal.

Dust Removal In a Brass Foundry. Walter B. Snow. Heating & Vent Mag—Oct., 07. 5 figs. 2700 w. 20c.

Foundry Construction.

An example of Good Foundry Construction. Castings—Oct., 07. 7 figs. 1700 w. 20c. Describes methods of handling pig iron, coke and return scrap at the plant of the Best Foundry Co., Bedford, Ohio.

Faults of Iron Castings.

Faults of Iron Castings. Forrest E. Cardullo. Mach—Oct., 07. 1200 w. 40c. First article of a series: gives points for the guidance of machine designers.

Foundry Metallurgy.

Foundry Metallurgy. Castings—Oct., 07. 7300 w. 20c. The first of a series of articles giving simple but scientific explanation of essentials of practical metallurgy.

Foundry Slags. Castings—Oct., 07. 1700 w. 20c. Discusses slags as they appear from the chemist's point of view.

Molding Practice.

Molding a Screw Propeller in Loam. Joseph F. Hart. Am Mach—Oct. 24, 07. 12 figs. 2400 w. 20c. Describes emergency method used, with indifferent facilities.

Molding Curved Pipe in Dry Sand. Am Mach—Oct. 31, 07. 4 figs. 1300 w. 20c.

Multiple Molding. James C. Mills. Modern Mach—Oct., 07. 2 figs. 2400 w. 20c.

Segmental Core Molding. H. J. McCaslin. Castings—Oct., 07. 6 figs. 2200 w. 20c.

Temporary Pattern and Method of Molding a Conveyor Pipe. Alfred Hibbs. Castings—Oct., 07. 8 figs. 1200 w. 20c.

Sand.

Preparation, Proportioning and Testing of Foundry Sand. J. Kraus, Stahl u Eisen —Oct. 16, 07. 6 figs. 3600 w. 60c.

HEATING AND VENTILATION.

Air Valves.

Air Valves for Steam Heating Systems. W. H. Wakeman. Dom Engg—Oct. 26, 07. 5 figs. 2300 w. 20c.

Anemometer.

A Recording Anemometer. J. Roger Preston. Met Wkr—Oct. 12, 07. 8 figs. 3000 w. 20c. Paper read before the Institution of Heating and Ventilating Engineers, London, England, Oct. 8.

Furnace Heating Rules.

Some Furnace Heating Rules and Their Explanation. Met Wkr—Oct. 12, 07. 2000 w. 20c. A brief statement and explanation of simple rules embodied in a paper recently read before the National Association of Sheet Metal Workers.

Heating Installations.

Heating and Ventilating the Commercial National Bank Building, Chicago.—I. Eng Rec—Oct. 26, 07. 1 fig. 4300 w. 20c.

Heating and Ventilating the United States Naval Academy. Heat & Vent Mag 10 figs. 1800 w. 20c. Shows method used in ventilating lecture halls having stepped floors.

Heating System of the St. Frances Home, Detroit, Mich. Eng Rec—Oct. 19, 07. 2 figs. 5400 w. 20c. Describes a scheme which combines hot-blast heating for dormitories, large dining room, chapel, etc., and direct radiation for the heating of all smaller rooms and for auxiliary heating in the larger public rooms.

Hot-Air Heating.

Blower System of Schoolhouse Heating. Dom Engg—Oct. 12, 07. 8 figs. 2800 w. 20c. Gives plans of a complete system with detailed description.

Charts Showing the Performance of Hot-Blast Coils. Burt S. Harrison. Heat & Vent Mag—Oct. 07. 3 charts. 900 w. 20c.

Hot Blast Heating. Charles L. Hubbard. Dom Engg—Oct. 5, 07. 3 figs. 1500 w. Oct. 19, 5 figs. 2000 w. Each 20c. Oct. 5: Disk fans. Oct. 19: Fan engines.

More Data Concerning Fan Heaters. E. T. Child. Met Wkr—Oct. 5, 07. 6 diags. 4000 w. 20c. Gives detailed investigation of the steam requirements and temperatures contained in pipe coil heaters.

Ventilating.

The Mechanical Ventilation and Warming of St. George's Hall, Liverpool, England. Chas. R. Hunnibal. Heat & Vent Mag—Oct., 07. 4 figs. 2200 w. Paper read before the British Institution of Heating & Ventilating Engineers, London, Oct. 8, 07.

Ventilation and Sanitation. A. E. Battle. Mar Engr & Nav Arch—Oct. 1, 07. 8 figs. 7600 w. 40c. Read at the Engineering and Machinery Exhibition, Olympia, London, before the members of the Institute of Marine Engineers, on Sept. 28, discusses subject with respect to conditions on shipboard.

HOISTING AND HANDLING MACHINERY.

Coal Handling.

Arrangements for Handling Coal Output. Floyd W. Parsons. Engg & Min J—Oct. 19, 07. 10 figs. 3300 w. 20c. Describes simple and efficient mechanical methods adopted for handling coal at mines under various conditions.

Cranes.

[illegible] for Force Required to Move Crane Trolleys. John S. Myers. Mach—Oct. 07. 3 figs. [illegible] w. [illegible]

The Latest Development of Locomotive Cranes. [illegible] Mach—Oct. [illegible] figs. [illegible] w. [illegible]

[illegible] Breakdown Cranes for the [illegible] Sept. [illegible] w. [illegible] Gives description [illegible] of these self-propelling cranes.

Elevators.

An Electric Incline Lift. El Engg—Sept. 26, 07. 2 figs. 1400 w. 40c.

The Hydraulic Elevator. William Baxter, Jr. Power—Nov., 07. 8 figs. 5200 w. 40c. XI. The Electrical features of vertical-cylinder elevators; operation and care of pilot valves and connecting mechanisms.

Mine Hoisting.

The use of Winding Ropes, Safety Catches and Appliances in Mine Shafts. Coll Guardn—Sept. 27, 07. 1 fig. 4700 w. Oct. 11. 6 figs. 7200 w. Each 40c. Report of the Transvaal Commission, appointed by the Governor of the Transvaal in 1905 to inquire into the subject.

Rapid Hoisting with Light Equipment. Min. & Sc Pr—Oct. 12, 07. 700 w. 20c.

Report of the Transvaal Commission on the Use of Winding Ropes, Safety Catches and Appliances In Mine Shafts.—I. Eng News—Oct. 31, 07. 6000 w. 20c.

Safety Hoisting Devices.

New Safety Devices for Hoisting Engines. J. Iverson. Z V D I—Oct. 5, 07. 15 figs. 6500 w. 60c.

HYDRAULIC POWER PLANTS.

Balanced Gate-Valve.

A New Design of Balanced Gate-Valve. Eng News—Oct. 17, 07. 2 figs. 500 w. 20c. Describes a double-seated, balanced gate-valve of new design, possessing features of advantage over the ordinary gate or disk valve.

Governors.

Mutual Reinforcement of Water-Wheel Governors. B. F. Groat. Eng News—Oct. 10, 07. 3 figs. 1300 w. 20c.

Hydro-Electric Plants.

Hydro-Electric Central Station of Charcani at Arequipa, Peru. Emile Guarini. El Rev—Oct. 5, 07. 2 figs. 2800 w. 20c.

Hydro-Electric Power and Transmission Plant at West Buxton, Maine. El Wld—Oct. 12, 07. 11 figs. 3100 w. 20c. Describes a 4,000-HP. development on the Saco River for supplying Portland.

Loch Leven Water Power Works. Engr (Lond)—Oct. 4, 07. 7 figs. 1500 w. 40c. Gives a general description of a new hydro-electric plant in Scotland.

The Hydro-Electric Plant of the West Kootenay Power & Light Co., Ltd., B. C. Eng Rec—Oct. 5, 07. 3 figs. 3500 w. 20c.

The New Power Plant of the Lowell Electric Light Corporation. El Wld—Oct. 5, 07. 3 figs. [illegible] w. 20c. Gives details of a new turbine power station now under construction.

Three Low-Head Hydro-Electric Developments in Michigan. Eng Rec—Oct. 19, 07. 10 figs. 9400 w. Oct. 26. 9 figs. 1400 w. Each 20c. Describes the systems of the Grand Rapids Muskegon Power Co. and the Commonwealth Power Co., at Big Rapids and Lyons.

Impulse Wheels, Large.

Large Impulse Wheels for a Brazilian Hydro-Electric Station. Eng Rec—Oct. 19, 07. 2 figs. 1000 w. 20c.

Pumps and Pumping Machinery.

Centrifugal Pumps. E. F. Doty. Engr—Oct. 15, 07. 7 figs. 1200 w. 20c.

Design of a Four-stage Turbine Pump. C. W. Clifford. Am Mach—Oct. 17, 07. 6 figs. 1100 w. 20c.

Modern Pumping and Hydraulic Machinery. Edward Butler. Mech Engr—Oct. 5, 07. 10 figs. 2500 w. Oct. 19. 9 figs. 3700 w. Each 40c.

Operating Reciprocating Steam Pumps By the Dense-Air System. Snowden B. Redfield. Comp Air—Oct., 07. 3 figs. 5800 w. 20c. Describes a method of operating a steam pump with high-pressure air which exhausts into a closed piping system leading back to the compressor intake, the pressure in this closed exhaust pipe being kept considerably above that of the atmosphere.

Prevention of Short-Stroking of Direct-Acting Duplex Pumping Engines. A. P. Blackstead. Eng News—Oct. 31, 07. 1200 w. 20c.

The Pittler Rotary Pump and Motor at the Olympia Exhibition. Engg—Sept. 27, 07. 12 figs. 1700 w. 40c. Gives details of a rotary pump and motor which have been applied to automobiles, giving a hydraulic drive: the pump is driven by a gasolene engine.

The Odesse Compound Steam-Pump at the Olympia Exhibition. Engg—Sept. 27, 07. 16 figs. 1800 w. 40c. Describes a steam pump designed to give as good results in the consumption of steam as the average fly-wheel pumping engine.

Velocity Meter.

A Simple Velocity Meter. G. S. Coleman. Surv—Sept. 27, 07. 1400 w. 40c.

INTERNAL COMBUSTION ENGINES.

Cost of Producer-Gas Power.

Cost of Generating Electricity by Small Gas Producer Plants. El Wld—Oct. 5, 07. [illegible]400 w. 20c.

Efficiency.

The Dependence of the Efficiency of a Gas Engine on the Proportion of the Gas-[illegible] Mixture. [illegible] Z V D I—Oct. 19, 07. 12 figs. [illegible] w. [illegible]

The Influence of the Ratio of Gas to Air on the Heat Efficiency of a Gas Engine. G. [illegible] Z V D I—Oct. 5, 07. 10 figs. 5500 w. [illegible]

Engine Losses.

Thermal and Power Losses in Internal-Combustion Engines. A. H. Burnand. Engg—Oct. 4, 07. 3 figs. 4200 w. Oct. 18. 1 fig. 3400 w. Each 40c. Gives data based upon experiments and deductions therefrom.

Gas Engines.

A Year's Experience with Gas Engines. Paul Windsor. St Ry Jl—Oct. 19, 07. 1500 w. 20c. Paper presented at the Atlantic City Convention of the Am. Street and Interurban R. E. Assn.

Chief Points of Difference Between the Gas Engine and the Steam Engine. William H. Booth. Power—Nov., 07. 3000 w. 40c.

Gas Engines and Suction Gas Plants. Hal Williams. Gas & Oil Power—Oct. 15, 07. 5400 w. 40c.

Gas Power Plants.

Gas-Power Central Station of the Duquesne Light Co., Pittsburg, Pa. Norman C. MacPherson. Eng Rec—Oct. 26, 07. 4600 w. 20c. Paper read before the American Institute of Electrical Engineers, Pittsburg Branch.

Producer Gas for Power Purposes. J. R. Bibbins. Ir Age—Oct. 3, 07. 7 figs. 8200 w. 20c. Discusses the efficiency of typical plants using hard and soft coals.

Gas Turbine.

New Gas Turbine and Centrifugal Air Compressor. Sc Am Sup—Oct. 12, 07. 3 figs. 2000 w. 20c. Describes the second improved turbine constructed by Messrs. Armengaud and Lemale, Paris.

Gas vs. Electric Power.

Comparative Economies in operating Small Motors By Gas, Gasolene and Electricity. J. H. Newbert. Prog Age—Oct. 15, 07. 1600 w. 20c. Read before the Pacific Coast Gas Association, Sept. 17-18.

Ignition.

Contract Method of Gas Engine Ignition. E. J. Edwards. El Wld—Oct. 19, 07. 1 fig. 2400 w. 20c. Describes the electrical factors to be considered in the design of a "contact" or "make-and-break" sparking equipment for a gas engine.

Electric Ignition for Internal Combustion Engines. Génie Civil—Sept. 21, 07. 6 figs. 2000 w. 60c. Describes the system devised by Sir Oliver Lodge.

Liquid Fuel.

Liquid Fuel for Internal Combustion Engines. R. W. A. Brewer. Mech Engr—Oct. 12, 07. 4400 w. 40c.

MACHINE PARTS.

Ball and Roller Bearings.

Ball and Roller Bearings.—I. J. F. Springer. Ir Age—Oct. 17, 07. 5 figs. 1600 w. Oct. 24. 10 figs. 6000 w. Each 20c. Discusses the use of separators for the purpose of reducing friction.

Ball Bearings. Mech Wld—Oct. 11, 07. 15 figs. 1700 w. 20c. Continued.

Test of Hardened Steel Balls. R. S. Stribeck. Z V D I—Sept. 21, 07. 14 figs. 6000 w. 60c. Second installment.

Crane Hooks.

Notes on Boat and Anchor Cranes.—I. Int Mar Engg—Nov., 07. 6 figs. 2400 w. 40c. Gives details of cranes and crane hooks representing the best recent practice.

Gears.

Design of Helical and Herringbone Gears. Charles H. Logue. Am Mach—Oct. 24, 07. 11 figs. 3300 w. 20c.

Intererfence in Involute Gears. C. C. Stitz. Am Mach—Oct. 10, 07. 5 figs. 1800 w. 20c. Gives graphical demonstrations, formulas and plotted diagrams for explaining the principles governing interference.

Strength of Bevel Gears. Chas. H. Logue. Am Mach—Oct. 17, 07. 1 fig. 900 w. 20c.

Friction Washers.

Test of Fiber Friction Washers. S. P. Yeo. Am Mach—Oct. 24, 07. 300 w. 20c.

Press Frame.

Designing a Press Frame. Am Mach—Oct. 10, 07. 2 figs. 3900 w. 20c.

Rope Drive.

Notes on Rope Drives at Various Angles. Mech Wld—Oct. 11, 07. 10 figs. 3100 w. 20c.

Developments of Change Gears. So Mach—Oct., 07. 2 figs. 3000 w. 20c.

Speed-Changing Devices.

A Variable-speed and Feed Mechanism. T. M. Lowthian. Am Mach—Oct. 17, 07. 2 figs. 1600 w. 20c. Shows in detail a new device for obtaining a multiplicity of changes for either speed or feed gears.

Speed Changing Mechanisms for Machine Tools. Franz Adler. Z V D I—Sept. 21, 07. 29 figs. 7000 w. Oct. 12. 26 figs. 6000 w. Each 60c.

The Solution of Bevel-Geared Epicyclic Trains. Am Mach—Oct. 24, 07. W. Owen. 3 figs. 2600 w. 20c.

Worm Gear.

Collier's Ball Worm Gear. W. H. Booth. Am Mach—Oct. 17, 07. 5 figs. 1700 w. 20c. Describes a curious form of worm-gear in which the teeth of the worm wheel are steel balls sunk to their equatorial line in cups bored in the body of the wheel.

MATERIALS.

Alloys.

Alloys. A. Humboldt Sexton. Mech Engr—Sept. 28, 07. 7 figs. 4600 w. 40c. XXI. Preparation of Alloys.

Copper-Clad Steel.

Monnot Copper-clad Steel. Am Mach—Oct. 3, 07. 2 figs. 1700 w. 20c. Describes successful methods of making rods or sheets with an iron or steel core and a copper covering to protect it from oxidization by water, gases and acids.

Ductile Metals.

The Hard and Soft States in Ductile Metals. Engg—Oct. 4, 07. 2500 w. 40c. Editorial discussion of a paper recently presented to the Royal Society by Mr. G. T. Beilby.

Lubricating Oils.

Lubricating Oils. J. H. Coste and E. T. Shelbourn. Pub Wks—Oct.-Dec., 07. 2 figs. 500 w. 60c. Discusses friction and the properties of various lubricants.

Malleable Castings.

Malleable Castings.—III. E. L. Rhead. Mech Engr—Oct. 5, 07. 12 figs. 2600 w. 40c.

Steel.

Further Experiments in the Aging of Mild Steel. C. E. Stromeyer. Ir & Cl Tr Rev—Sept. 27, 07. 29 figs. 8500 w. 40c. Paper read at the Vienna meeting of the Iron & Steel Inst., Sept. 23-24.

Hardened Steels. Percy Longmuir. Ir & Cl Tr Rev—Sept. 27, 07. 12 figs. 4000 w. 40c. Paper read at the Vienna meeting of the Iron & Steel Inst., Sept. 23, 07.

Vanadium and Vanadium Steel.

Extension in the Use of Vanadium. Baxeres De Alzugaray. Min Wld—Oct. 5, 07. 900 w. 20c.

Vanadium Steel. E. F. Lake. Mach—Oct., 07. 18 figs. 1600 w. 40c. Sets forth the characteristics of this new alloy steel for machine construction.

The Present Source and Uses of Vanadium. J. Kent Smith. Trans Am Inst Min Engrs—Sept., 07. 2300 w. $2.00. Paper read at the Toronto meeting, July, 1907.

Vanadium and Its Effect on Steel and Copper Alloys. Met Indus—Oct., 07. 1600 w. 20c.

MECHANICAL DRAFTING.

Detail Drawings, System of.

A Practical System of Detail Drawings. Bruce C. McAlpine. Am Mach—Oct. 17, 07. 3 figs. 1500 w. 20c.

Drafting Room, Location of.

The Drafting Room, Its Location and Work. Oscar E. Perrigo. Ir Tr Rev—Oct. 3, 07. 4 figs. 3500 w. 20c. The first of a series of articles on shop management and cost keeping.

Geometrical Construction.

Drawing a Circular Arc Tangent to a Given Arc and to a Given Straight Line at a Given Point. H. V. Purman. Am Mach—Oct. 17, 07. 3 figs. 800 w. 20c.

Photographing Machinery.

Photographing Machinery. Am Mach—Oct. 10, 07. 4 figs. 1900 w. 20c. Gives instructions for obtaining good photographs for reproduction.

Tool Chest.

A Draftsman's Tool Chest. I. G. Bayley. Mach—Oct., 07. 4 figs. 1100 w. 40c.

MECHANICS.

Temperature Stresses in a Hollow Sphere. A. Leon and A. Basch. Zeit d. Oest Ing u Arch—Oct. 11, 07. 2 figs. 3000 w. 60c.

The Effect of Hardening and Tempering on the Dimensions of Steel. John Phin. Am Mach—Oct. 17, 07. 600 w. 20c.

The Loading of Crane Hooks and Other Curved Beams. C. Pfleiderer. Z V D I—Sept. 21, 07. 8 figs. 5000 w. 60c.

METAL WORKING.

Bodies with Spiral Holes.

Method of Producing Bodies with Spiral Holes. E. D. Sewall. Am Mach—Oct 10, 07. 4 figs. 900 w. 20c.

Case-Hardening.

Case-Hardening. G. Shaw Scott. Ir & Cl Tr Rev—Sept. 27, 07. 11 figs. 5200 w. 40c. Paper read before the Vienna Meeting of the Iron & Steel Inst. Sept. 23-24.

The Case-Hardening of Mild Steel. C. O. Bannister and W. J. Lambert. Ir & Cl Tr Rev—Sept. 27, 07. 22 figs. 2600 w. 40c. Paper read at the Vienna Meeting of the Iron & Steel Inst., Sept. 23-24.

Dies for Plastic Materials.

Making Dies for Plastic Materials. Am Mach—Oct. 24, 07. 2600 w. 20c.

Drop Forging.

Drop-Forging Methods and Interesting Work. Am Mach—Oct. 10, 07. 7 figs. 3000 w. 20c. Describes manufacture of drop-forgings with well-installed equipment and shows some difficult forgings and their dies.

Extruded Tubes and Shapes.

Cold-Extruded Tubes and Shapes. P. Breuil. Génie Civil—Oct. 5, 07. 7 figs. 3000 w. 60c. First article describing methods used in the manufacture of copper, zinc and aluminum tubes by the Société Francaise de Métallurgie.

Making Tubes by the Extrusion or "Squirting" Process. Am Mach—Oct. 10, 07. 2 figs. 1300 w. 20c.

Files.

Examining and Testing Files. Oscar E. Perrigo. Machy—Oct., 07. 2 figs. 2000 w. 40c.

Making Swiss Files in America.—II. Machy—Oct., 07. 6 figs. [illegible] w. 40c.

Fits, Metric.

Newall Standard Limits for Fits in Metric Dimensions. J. F. Story. Am Mach—Oct. 24, 07. 600 w. 20c.

Fly Cutter as Reference Gage.

The Fly Cutter as a Reference Gage. Am Mach—Oct. 24, 07. 4 figs. 1500 w. 20c. Supplements a previous article and shows further uses of the fly cutter.

Gear Cutting.

A Novel Gear Shaper. Frank C. Hudson. Am Mach—Oct. 3, 07. 4 figs. 1300 w. 20c.

Cutting Bevel Gears with a Rotary Cutter. H. P. Fairfield. Machy—Oct., 07. 19 figs. 2100 w. 40c. Profusely illustrated article showing each step taken.

Graduating in the Lathe.

Method of Graduating in the Lathe. Wm. C. Force. Machy—Oct., 07. 3 figs. 500 w. 40c.

Hardening and Tempering Steel.

Hardening and Tempering High-Speed Steel. James Steele. Am Mach—Oct. 17, 07. 1600 w. 20c.

The Hardening of Steel. L. Demozay. Ir & Cl Tr Rev—Sept. 27, 07. 49 figs. 8500 w. 40c. Paper read at the Vienna meeting of the Iron & Steel Inst. Sept. 23-24.

Key Planing.

Planing Fixtures for Round-Edge Keys. R. H. Wadsworth. Am Mach—Oct. 24, 07. 5 figs. 800 w. 20c.

Layout of "Y" Connection.

Layout of a Large "Y" Connection. Emmet S. Hegerty. Boiler Maker—Nov., 07. 7 figs. 2500 w. 20c.

New Machine Tools.

A Novel 16-Spindle Drill. Am Mach—Oct. 24, 07. 3 figs. 700 w. 20c.

Machinery at Olympia. Engr (Lond)—Sept. 27, 07. 9 figs. 5300 w. 40c. Describes new machine tools and appliances shown at this exhibition.

The Engineering and Machinery Exhibition, Olympia.—I. Joseph Horner. Engg—Sept. 27, 07. 14 figs. 7600 w. 40c.

Power Required by Machine Tools.

Power Required for Drive Machine Tools. H. B. Emerson. Am Mach—Oct. 10, 07. 3600 w. 20c.

Power Values for Machine Tools in Groups. L. P. Alford. Am Mach—Oct. 31, 07. 1500 w. 20c. Gives tables of the horse-power required for 150 machine tools of standard shapes and sizes showing how these values were obtained.

Reamers.

Reamers.—III. Erik Oberg. Mach—Oct., 07. 4 figs. 2200 w. 40c.

Screw Cutting.

Cutting a Quick Pitch Screw in the Lathe. Wm. V. Lowe. Am Mach—Oct. 24, 07. 2 figs. [illegible] w. 20c.

Screw Machines.

Speeds and Feeds for Screw Machine Work. C. L. Goodrich and F. A. Stanley. Am Mach—Oct. 10, 07. 2200 w. 20c.

The Camming of Automatic Screw Machines.—II. C. L. Goodrich and F. A. Stanley. Am Mach—Oct. 3, 07. 2 figs. 4800 w. 20c. Shows how the changeable pulleys and gears affect the tool feeds and the two-speed spindle drive modifies the cam angles.

Soldering.

Experiments on Soldering. El Rev (Lond)—Oct. 4, 07. 2 figs. 3800 w. Oct. 11. 4500 w. Each, 40c.

Tool Inspection.

Inspecting Tools With the Test Indicator. J. H. Boulet. Am Mach—Oct. 17, 07. 11 figs. 2700 w. 20c. Describes the utilization of the Universal Indicator in the tool-making department for the inspection of various classes of work.

SHOPS AND BUILDINGS.

Inter-Shop Accounting.

Accounting Relations of the Foundry and Pattern Shop. R. W. McDowell. Castings—Oct. 07. 4 figs. 2600 w. 20c. Describes the interdependence of the items that make up equipment, material in process of manufacture, depreciation, charges and credits.

Shop Efficiency.

Shop Efficiency. H. W. Jacobs. Am Engr & Rd Jl—Oct., 07. 7 figs. 2300 w. 40c. Discusses efficiency records of individual workmen, gangs and shop forces.

Tredegar Plant.

A Historic Iron Works. Geo. D. Morgan. Ir Age—Oct. 17, 07. 3 figs. 2400 w. 20c. Describes the Tredegar Company's plant, Richmond, Va.

STEAM POWER PLANTS.

Altitude: Effect on Engine Power and Economy.

How Does Altitude Affect Steam-Engine Power and Economy? Otto H. Mueller. Power—Nov., 07. 1 fig. 900 w. 40c.

Boiler Inspection Rules.

Rules for Boiler Inspection. Boiler Maker—Nov., 07. 5100 w. 20c. Gives rules formulated by the Massachusetts Board of Boiler Inspection.

Boiler Repairs.

New Method of Effecting Boiler Repairs. Harry Rack-Keene. Mar Engr & Nav Arch—Oct. 1, 07. 16 figs. 5500 w. 40c. Read at the Engineering and Machinery Exhibition, Olympia, London, before the members of the Institute of Marine Engineers, Sept. 28, 07.

Calorimeter.

The Thomas Steam Calorimeter. Carl C. Thomas. Power—Nov., 07. [illegible] figs. [illegible] w. [illegible] designed for determining [illegible] of steam at different points [illegible] can be used with steam of [illegible] degree of wetness and of any [illegible] pressure above that in the condenser.

Circulation of Water in Boiler Tubes.

Circulation of Water and Heat Transmission Through Boiler Tubes. L. P. Breckenridge. Engr—Oct. 15, 07. 4 figs. 2700 w. 20c.

Cost of Power.

The Cost of Power as a Fixed Charge. L. C. Read. Can Engr—Oct. 4, 07. 3700 w. Paper read at the Canadian Manufacturers' Assn. at Toronto, Sept. 26, 07.

Engine Foundations.

Engine Foundations. Prac Engr—Sept. 27, 07. 8 figs. 2100 w. Oct. 11. 3 figs. 2200 w. Each, 40c.

Feed Pump.

Feed-Up Pump for Use with Superheated Steam; Olympia Exhibition. Engg—Sept. 27, 07. 3 figs. 700 w. 40c.

Fuels and Steam Production.

Coalite. S. W. Parr. Engg & Min Jl—Oct. 19, 07. 1600 w. 20c.

Some Experiments to Determine the Amount of Volatile Matter in Coal. A. Bement. Chem Engr—Sept., 07. 1 fig. 3000 w. 40c.

Steam Production From the Cheaper Grades of Anthracite. W. D. Ennis. Eng Mag—Nov., 07. 5200 w. 40c. Discusses the mechanical problems of air supply, grate and heating surfaces, stoking, draft, etc., which affect their economical use in the boiler furnaces.

Technical Aspects of Oil as Fuel.—II. F. E. Junge. Power—Nov., 07. 16 figs. 5400 w. 40c.

The Utilization of Peat for Power Purposes with the Recuperation of Byproducts. Electrochem & Met Ind—Oct., 07. 3000 w. 40c. Based on German practice as described by Prof. A. Frank.

Indicators.

The Indicator, Its Election, Application and Uses. Hubert E. Collins. Cld Str & Ice Tr Jl—Oct., 07. 16 figs. 3300 w. 20c.

Use of the Hatchet Planimeter. R. T. Strohm. Prac Engr—Oct., 07. 2 figs. 2500 w. 20c. Gives instructions for making an instrument for finding the M. E. P. of indicator cards.

Inertia Pressure and Engine Speed.

Inertia Pressure as a Rational Measure of Engine Speed. Sanford A. Moss. Sibley Jl of Engg—Oct., 07. 3500 w. 40c. —I. Inertia pressure as a factor in engine occurrences.

New Power Plants.

Power Plant of the Gulfport and Mississippi Coast Traction Co. Earl F. Scott. Eng Rec—Oct. [illegible], 07. 2 figs. 2500 w. 20c.

The Park Royal Generating Station of the Great Western Railway, London. El Wld—Oct. 19, 07. 7 figs. 3900 w. 20c.

Power Plant Construction.

Modern Power Station and Electrical Construction. W. A. Haller. Jl of Assoc Engg Socs—Sept., 07. 7 figs. 7100 w. 40c. Paper read before the Louisiana Engineering Society at its meeting, May 13.

Steam Turbines.

Curtis Turbines in Railway Service. August H. Kruesi. St Ry Jl—Oct. 10, 07. 3 figs. 1600 w. 20c. Paper presented at the Atlantic City Convention of the Am. Street & Interurban R. E. Assn.

Economy Tests of a 7,500-KW. Westinghouse-Parsons Steam Turbine. J. R. Bibbins. Eng News—Oct. 10, 07. 1 fig. 2100 w. 20c.

Modern European and American Steam Turbines. Jl of El Power & Gas—Oct. 26, 07. 2 figs. 2500 w. 20c.

Notes on the Use of Low-Pressure Steam in Connection with Engine Exhaust. J. R. Bibbins. El Jl—Oct., 07. 1 fig. 1000 w. 20c.

Parsons Type Steam Turbines. Charles H. Naylor. Engr (Lond)—Oct. 4, 07. 8 figs. 4200 w. 40c. Discusses the flow of steam through the bladed part of the turbine, with respect to areas, angles and forms of blades.

Practical Experience With Exhaust-Steam Turbines. A. Gradenwitz. Eng News—Nov., 07. 14 figs. 5700 w. 40c. Shows the economies which may be effected by the installation of low-pressure turbines for the utilization of exhaust steam.

Recent Developments in Steam Turbine Power Station Work, with Special Reference to The Fort Wayne & Wabash Valley Traction Company Spy Run Station. J. R. Bibbins. St Ry Jl—Oct. 19, 07. 12 figs. 6300 w. 20c. Paper presented at the Atlantic City Convention of the Am. Street & Interurban R. E. Assn.

Some Practical Points in Steam Turbine Construction; With Particular Reference to the Parsons Type. St. John Chilton. St Ry Jl—Oct. 19, 07. 6 figs. 4500 w. 20c. Paper presented at the Atlantic City Convention of the Am. Street & Interurban R. E. Assn.

Temperature-Entropy Diagram.

The Transformation of Heat Into Work. Sidney A. Reeve. Power—Nov., 07. 8 figs. 5600 w. 40c. A simple introduction to the temperature-entropy diagram in which the conversion of various forms of energy are graphically described.

Valve Gears.

Recke-Ruston Positive Valve-Gear. Engg—Sept. 27, 07. 10 figs. 500 w. 40c. Describes a mechanism which opens and closes the valves without shocks and in which backlash is avoided.

The Marshall Valve Gear. Engg Times—Oct. 17, 07. 2 figs. 500 w. 40c. Describes a simplified slide-valve gear, giving a steam distribution similar to that of a Corliss engine.

WOODWORKING.

The Grinding of Wood-Working Tools. C. C. Bosworth. Wood Craft—Oct., 07. 4 figs. 4000 w. 20c. Describes the grindstone and other abrasives, their peculiarities and methods of effectively using them.

METALLURGY

COPPER.

Electrolytic Determination.

Short Electrolytic Copper Determination. Persifor G. Spillsbury. Engg & Min Jl—Oct. 26, 07. 2 figs. 1400 w. 20c.

Rolling Sheet Copper.

The Rolling of Sheet Copper. Met Wkr—Oct. 5, 07. 2600 w. 20c. Describes the type of rolling mills used and the general methods of the copper rolling companies in the manufacture of sheet copper.

Smelting.

Metallurgical Calculations. J. W. Richards. Electrochem & Met Ind—Oct., 07. 10,000 w. 40c. The Electrometallurgy of Copper: Electrolytic Processes; gives problems.

Notes on Copper. A. Humboldt Sexton. Mach Engr—Oct. 12, 07. 2 figs. 5700 w. 20c. VIII. Modern Methods of Copper Smelting. Running for Regulus.

Smelting Works of the Consolidated Mining & Smelting Company of Canada, Ltd., at Trail, B. C. J. M. Turnbull. Can Min Jl—Oct. [illegible], 07. 4 figs. 5700 w. 40c.

GENERAL METALLURGY.

Electro-Metallurgy.

Applied Electro-Metallurgy Up to the End of 1906. J. B. C. Kershaw. Eng Mag—Nov., 07. 16 figs. 5700 w. 20c. Deals with the electro-metallurgy of the ferro-alloys, iron and steel, lead, nickel, siloxicon, silicon, sodium, tin and zinc.

Production of Phosphorus in the Electric Furnace. Electrochem & Met Ind—Oct., 07. 2500 w. 40c. Extracts from a recent publication of the U. S. Geological Survey.

Pyrometry.

Optical Pyrometry. Engg—Oct. 18, 07. 7 figs. 2300 w. 40c. Paper read before Section A of the British Association at Leicester.

GOLD AND SILVER.

Chlorination.

Chlorination of Gold Ores: Laboratory Tests. A. L. Sweetser. Min Rep—Oct. 17, 07. [illegible] w. 20c. VI. Discussion of Tests.

Concentration.

Concentration Upside Down. Walter R. Ingalls. Engg & Min Jl—Oct. 26, 07. 6 figs. 6700 w. 20c. Describes a new process of ore separation in which sulphide minerals are sustained by the surface tension of the water, while rock constituents are affected by it negatively and sink.

Cyaniding.

Decent Advances in Cyanidation in Mexico. J. Leslie Mennell. Min Wld—Oct. 11, 07. 3800 w. 20c.

The Cyanide Process at the Portland (Colo.) Mill. Min Rep—Oct. 24, 07. 2800 w. 20c.

Litharge in Silver Assay.

Effect of High Litharge in Crucible Assay for Silver. Richard W. Lodge. Min Rep—Oct. 17, 07. 1900 w. 20c. Paper read at the Toronto meeting of the A. I. M. E., July, 1907.

Milling.

Milling Practice at the Granadena Mill. S. F. Shaw. Eng & Min Jl—Oct. 5, 07. 2 figs. 1700 w. 20c.

Stamp Mill Records. E. Percy Brown. Can Min Jl—Oct. 1, 07. 900 w. 40c.

Tails and Sludge Milling. W. D. Glenn. Mines & Min—Nov., 07. 1 fig. 1200 w. 40c. Describes a new method of treatment, equipment and pulp flow; used in the Old Jude Mine, Oronogo, Mo.

The Desert Mill. A. B. Parsons. Min & Sc Pr—Oct. 19, 07. 6 figs. 5900 w. 20c. Describes a 100-stamp mill and power plant at Millers, Nevada.

The Milling Practice at El Oro Mine, Mexico. E. Burt. Min Wld—Oct. 26, 07. 4 figs. 1500 w. 20c.

Ore Treatment.

Notes on Waihi Ore Treatment. Ralph Stokes. Min Jl—Sept. 28, 07. 6 figs. 2700 w. 40c. Paper read before the Chemical, Metallurgical & Mining Society of South Africa.

Slimes, Treatment of.

Recent Improvements in the Art of Slimes Treatment. D. J Kelly. Min Jl—Oct. 5, 07. 4000 w. 40c. Paper read before the Utah Section of the Western Association of Technical Chemists and Metallurgists.

IRON AND STEEL.

Austrian Iron Industry.

[illegible] Industry. Wilhelm [illegible] Sept [illegible] w. 40c. [illegible] the Iron and Steel Inst. [illegible]

Blast Furnaces.

[illegible] Horace Allen. Ir Tr Rev [illegible] figs. 5000 w. 20c. [illegible] of Waste Gases.

The Determination of the Total Quantity of Blast-Furnace Gas for a Given Make and Its Calorific Value. Prof. Joseph Von Ehrenwerth. Ir & Cl Tr Rev—Sept. 27, 07. 1800 w. 40c. Paper read at the Vienna meeting of the Iron & Steel Inst. Sept. 23-24.

The Economic Distribution of Electric Power from Blast Furnaces. B. H. Thwaite. Ir & Cl Tr Rev—Sept. 27, 07. 1 fig. 3700 w. 40c. Paper read at the Vienna meeting of the Iron & Steel Inst., Sept. 23-24.

Zinc in the Blast Furnace. John J. Porter. Ir Age—Oct. 24, 07. 3000 w. 20c. Read at the Toronto meeting, July, 1907, of the American Institute of Mining Engineers.

Blow-Holes in Ingots.

Blow-Holes in Steel Ingots. E. Von Maltitz. Trans Am Inst of Min Engrs—Sept., 07. 10,200 w. $2.00. Paper read at the Toronto meeting, July, 07.

Crude Oil in Converters.

Use of Crude Oil in Converters. W. B. Rountree Eng & Min Jl—Oct. 5, 07. 1 fig. 200 w. 20c.

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A By-Product Charcoal Iron Plant at Marquette, Mich. Eng Rec—Oct. 12, 07. 1 fig. 3600 w. 20c.

Krupp Steel Works at Rheinhausen. Stahl u Eisen—Oct. 19, 07. 63 figs and plates. 7200 w. 60 c.

The Krupp Works in Germany. J. B. Van Brussel. Ir Tr Rev—Oct. 3, 07. 20 figs. 6000 w. 20c. Describes the various plants, comprising blast furnaces, steel mills, gun and armor plate shops.

Metallurgy and Physical Chemistry.

Application of the Laws of Physical Chemistry in the Metallurgy of Iron. Baron H. Von Juptner. Ir & Cl Tr Rev—Sept. 27, 07. [illegible] figs. 10,200 w. 40c. Paper read at the Vienna meeting of the Iron & Steel Inst., Sept. 23-24.

Puddling.

Mechanical Puddling: The Danks Revolving Puddling Furnace. Ir Age—Oct. 17, 07. 2900 w. 20c. Communication reviewing the history of mechanical puddling, from Mr. J. G. Danks.

Steel and Meteoric Iron.

Steel and Meteoric Iron. Prof. F. Berwerth. Ir & Cl Tr Rev—Sept. 27, 07. 3 figs. [illegible] w. 40c. Paper read at the Vienna meeting of the Iron & Steel Inst. Sept. 23-24.

Tungsten in Steel.

The Determination of Tungsten in Steel in the Presence of Chromium. F. Willy [illegible]. Stahl u Eisen—Oct. 2, 07. [illegible] w. [illegible]

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Ore Treatment.

Process or Treatment of Complex Zinciferous Ores. Mr. Bechi and R. W. Bucker. Min Jl—Oct. 19, 07. 1700 w. 40c. From the "Révue Chimique," October, 1907.

Smelting.

Electric Zinc Smelting. Min Rep—Oct. 24, 07. 1800 w. 20c. Trans. Tri-State Mining Assn. Paper read at Mineral Point, Wis., meeting, Sept., 07.

Physical Factors in the Metallurgical Reduction of Zinc Oxide. Woolsey McA. Johnson. Trans Am Inst Min Engrs—Sept., 07. 3000 w. $2.00. Paper read at the Toronto meeting, July, 07.

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Construction of Tracks in Coal Mines. M. S. Hachita. Eng & Min Jl—Oct. 5, 07. 9 figs. 2200 w. 20c. Describes methods of laying tracks for haulage roads, the laying-out of frogs, switches, etc.

Inflammability of Coal Dust. Dr. P. Phillips and Henry Widdas. Ir & Cl Tr Rev—Oct. 18, 07. 1 fig. 4400 w. 40c. Paper read at the North of England Institute of Mining and Mechanical Engineers.

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Electric Railway Review, Chicago.
Electrical World, New York.
Electrical World, New York.
Engineering-Contracting, Chicago.
Engineering News, New York.
Engineering Record, New York.
Iron Age, New York.
Mines and Minerals, Scranton, Pa.
Railway Age, Chicago.
Roadmaster and Foreman, Chicago.
Street Railway Journal, New York.

Phonographs:
Duplex Phonograph Co., 303 Patterson St., Kalamazoo, Mich.

Piling, Steel:
Wemlinger Steel Piling Co., 11 Broadway, New York.

Polishing Machines:
Tanite Co., Stroudsburg, Pa.

Pumps:
Rife Hydraulic Ram Co., R. 2160 Trinity B., New York.

Punches, Hydraulic:
Richard Dudgeon, 26 Columbia St., New York.

Railway Supplies:
American Ry. Supply Co., 24 Park Pl., New York.

Schools and Colleges:
American School of Correspondence, Chicago, Ill.
Armour Institute of Technology, Chicago.
Clarkson School of Technology, Potsdam, N. Y.
Lehigh University, South Bethlehem, Pa.
Ohio Northern University, Ada, Ohio.
Rose Polytechnic Institute, Terre Haute, Ind.
University of Michigan, Ann Harbor, Mich.

Signal Wire:
India Rubber & G. P. Ins. Co., 253 Broadway, New York.

Speed Indicators:
Tanite Co., Stroudsburg, Pa.

Steel Piling:
Wemlinger Steel Piling Co., Bowling Green Offices, N. Y.

Structural Steel Computer:
Edge Computer Sales Agency, 220 Broadway, New York.

Talking Machines:
Duplex Phonograph Co., 303 Patterson St., Kalamazoo, Mich.

Tanks:
Baltimore Cooperage Co., Baltimore, Md.

Testing Laboratories:
Dr. Peter T. Austen, 89 Pine St., New York.
Meade Testing Laboratory, Nazareth, Pa.
Michigan Testing Laboratory, Detroit, Mich.
Monadnock Laboratories, Chicago, Ill.

Time Checks:
American Ry. Supply Co., 24 Park Pl., New York.

Time Stamps:
Automatic Time Stamp Co., 164 Congress St., Boston, Mass.

Towers:
Baltimore Cooperage Co., Baltimore, Md.

Tube Expanders:
Richard Dudgeon, 26 Columbia St., New York.

Vanadium:
Vanadium Alloys Co., 25 Broad St., New York.

Water Supply:
Rife Hydraulic Ram Co., R. 2160 Trinity B., New York.

Wire, Insulated:
India Rubber & G. P. Ins. Co., 253 Broadway, New York.

Wood-Workers' Tools:
Tanite Co., Stroudsburg, Pa.

Water Supplies.

Small Water Supplies. H. C. H. Shenton. Pub Wks—Oct.-Dec., 07. 8 figs. 10,000 w. 60c. Discusses the obtaining of water from various sources and the geological side of the question of water supply.

The Outlook for Pure Water Supplies in New York State. Prof. Henry N. Ogden. Corn C Engr—Oct., 07. 3600 w. 40c.

Valuation of Water Works Properties.

Valuation of Water Works Properties. Chas. B. Burdick. Engg-Contr—Oct. 23, 07. 5100 w. 20c. Abstract of paper read before Wisconsin League of Municipalities.

MISCELLANEOUS.

Municipal Motor Cars.

Municipal Cars for Municipal Work. Mun Jl & Engr—Oct. 2, 07. 13 figs. 3300 w. 20c. Describes gasolene, electric and steam motors for fire apparatus; street sprinklers and sweepers; refuse wagons; police patrol and ambulances; runabouts for street department, etc.

Municipal Ownership.

Municipal Ownership of Public Utilities. John W. Hill. Eng News—Oct. 10, 07. 4700 w. 20c.

RAILROAD ENGINEERING

CONSTRUCTION.

Africa.

The Amabele-Butterworth Railway, South Africa. Eng Rec—Oct. 5, 07. 3 figs. 1800 w. 20c.

The Otavi Railway in South Africa; the Longest 24-in. Gage Railway in the World. Eng News—Oct. 10, 07. 3 figs. 4300 w. 20c.

Australia.

The Railways of Australia. P. Privat Deschanel. Génie Civil—Sept. 21, 07. 2000 w. 60c. Concluding article, discussing transcontinental projects.

Brazil.

The Survey of the Madeira and Mamoré R. R. in Brazil. Ernest H. Liebel. Eng-News—Oct. 24, 07. 2 figs. 8100 w. 20c.

Earth Slides.

Earth Slides. Eng Rec—Oct. 5, 07. 1900 w. 20c. Notes by H. Rohwer, contributed to a recent bulletin of the Am. Ry. Eng. and M. of W. Asso., based on his long experience in railway work.

Florida East Coast.

Florida East Coast Railway—Key West Extension. Howard Egleston. Engg-Contr—Oct. 2, 07. 4 figs. 1100 w. Oct. 16. 3 figs. 2400 w. Each 20c. Roadbed construction and temporary trestle work.

Northern Pacific Ry.

The New Tacoma-Tenino Line of the Northern Pacific. H. Cole Estep. R R Gaz—Oct. 11, 07. 1000 w. 20c.

MANAGEMENT AND OPERATION.

Demurrage.

Reciprocal Demurrage. W. Hayward Drayton. Ry Age Oct. 4, 07. 2100 w. 20c An address delivered before the Traffic Bureau of the Illinois Manufacturers' Association at Chicago, Sept. 27.

Maintenance and Inspection of Equipment.

Report of the Committee on Maintenance and Inspection of Electrical Equipment. J. Lindall, W. D. Wright, E. T. Munger and L. L. Smith. St. Ry Jl—Oct. 19, 07. 3 figs. 8100 w. 20c. Paper presented at the Atlantic City Convention of the Am. Street & Interurban R. E. Assn.

Structure Design, Effect on Economy.

The Influence of the Design of Railway Structures on Economy of Operation. H. T. Campion and William McClellan. St Ry Jl—Oct. 19, 07. 12 figs. 4600 w. 20c. Paper presented at the Atlantic City Convention of the American Street & Interurban Railway Association, Oct. 16.

POWER AND EQUIPMENT.

Disinfecting Cars.

Notes on the Disinfection of Railway Cars at Terminals. H. E. Smith. Eng News—Oct. 17, 07. 2100 w. 20c. From a paper read before the Master Car and Locomotive Painters' Assn., Sept. 10, 07.

Dynamometer Cars.

New Dynamometer Car for the Pennsylvania Railroad. Eng News—Oct. 17, 01. 7 figs. 5100 w. 20c. Describes latest (fifth) car having a measuring capacity of 100,000 lbs.

North-Eastern Railway Dynamometer car. Engr (Lond)—Oct. 4, 07. 4 figs. 1600 w. 40c.

Locomotives.

A Method of Plotting Locomotive Characteristics. Lawford H. Fry. Am Engr & Rd Jl—Oct., 07. 2400 w. 40c.

Causes of Defects and Failures of Steel Tires. Geo. L. Norris. R R Gaz—Oct. 25, 07. 29 figs. 18,000 w. 20c. First installment of paper read at October meeting of the Western Railway Club.

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Express Locomotives for the Prussian State Railways. Engg—Oct. 11, 07. 22 figs. 2300 w. 40c. Describes the latest type of six-coupled express locomotive on the Prussian state railways, which is fitted with the Schmidt type of smoke-tube superheater.

Locomotive Coals. A. Jacobsen. Engr (Lond)—Oct. 18, 07. 1 fig. 4200 w. 40c.

Pusher Locomotives of the Mallet Duplex Type for the Erie Ry. Eng News—Oct. 3, 07. 1 fig. 2100 w. 20c.

Superheating with Compound Locomotives. Ry & Engg Rev—Oct. 5, 07. 6 figs. 3900 w. 20c. Extract from a pamphlet issued by Herr Wm. Schmidt.

The Calculation of Locomotive Axle Loads. A. Kutschere. Zeit Oest Ing u Arch—Oct. 11, 07. 12 figs. 4500 w. Oct. 18. 5 figs. 5000 w. Each 60c.

The Development of the American Locomotive. Jl Franklin Inst—Oct., 07. 18 figs. 7300 w. $1.00. Report of the Committee on Science and the Arts on the Contribution of the Baldwin Locomotive Works.

The Repair of Locomotive Tube Plates. Engr (Lond)—Sept. 27, 07. 5 figs. 1000 w. 40c. Describes a system of repairing the copper tube plates of locomotive fireboxes by means of thin sheet copper patches secured by plain copper ferrules.

Motor Car.

Steam Motor Car, Intercolonial Railway. Am Engr & R R Jl—Oct., 07. 11 figs. 1900 w. 40c.

Mountain Railway.

The Puy-De-Dome Mountain Railway. Eng News—Oct. 10, 07. 3 figs. 1800 w. 20c. Describes French traction system employing a friction grip on a centre rail.

Signaling.

A Method of Uniform Signaling. Ry & Eng Rev—Oct. 12, 07. 2 figs. 1900 w. 20c. Report of a special committee on "Interlocking and Block Signals" presented at the annual meeting of the Railway Signal Assn., Milwaukee, Wis., Oct. 9.

How to Remedy Effects of Foreign Current on Automatic Block Signals. Ry & Eng Rev—Oct. 12, 07. 1100 w. 20c. Report presented at the annual meeting of the Railway Signal Assn., Milwaukee, Wis., Oct. 10.

Railway Signaling. J. B. Struble. Fr Jl—Oct., 07. 3 figs. 1700 w. 20c. VIII. Automatic block signaling, alternating current double-rail return system, direct-current train propulsion.

Track Circuits for Illuminated Track Indicators. N. Y. C. & H. R. R. R. Ry Engg & M of W—Oct., 07. 3 figs. [illegible] w. 20c.

Steel Coach.

New [illegible] Steel Railway Coach. Ry & Eng Rev—Oct. [illegible], 07. [illegible] figs. [illegible] w. 20c.

Track.

Greater Loads on Rails. H. V. Wille. Ir Age—Oct. 3, 07. 8 figs. 3200 w. 20c. Describes the increase in weights of Baldwin Locomotive Works engines since 1885.

Rail Corrugation. A. L. C. Fell. El Rev (Lond)—Oct. 4, 07. 3800 w. 40c. Paper read at the Municipal Tramways Convention, Manchester.

Standard Roadbed Cross-Sections. I. C. R. R. Ry Engg & M of W—Oct., 07. 6 figs. 700 w. 20c.

Steel Tie and Concrete Construction on the Utica and Mohawk Valley Railway System, Utica, N. Y. M. J. French. St. Ry Jl—Oct. 12, 07. 4 figs. 4400 w. 20c. Discusses city track construction problems and describes the steel tie and concrete track construction built under the author's directions, giving details of cost and labor.

The Hardness of Corrugated Rails. George L. Fowler. St Ry Jl—Oct. 5, 07. 3 diagrams. 1500 w. 20c. Describes recent tests upon corrugated rails, showing apparently that corrugations are not due to defects in the rolling process.

Tie Plates and Wooden Foot Guards. C. R. I. & P. Ry. Ry Eng & M of W—Oct., 07. 2 figs. 600 w. 20c.

Track Elevation Details (Chicago) C. & W. I. R. R. Ry Eng and M of W—Oct., 07. 4 figs. 600 w. 20c.

Turntables.

Modern Turntables.—II. Ry Age—Oct. 25, 07. 10 figs. 1600 w. 20c.

Water Softening Plant.

Water Softening and Purification Plant of the Pennsylvania Railroad at Hartsdale, Ind. Ir Tr Rev—Oct. 10, 07. 6 figs. 2800 w. 20c.

Yard.

The Pitcairn (Pa.) Yard of the Pennsylvania Railroad. Eng Rec—Oct. 12, 07. 1 fig. 4900 w. 20c.

STREET AND ELECTRIC RAILWAYS.

Electrically Equipped Roads.

Combination Direct-Current and Single-Phase Equipment for the Vienna-Baden Railway. St Ry Jl—Sept. 28, 07. 6 figs. 2100 w. 20c. Describes motor and control equipment and gives performance curves.

Electrical Equipments of Main Line Railroads in Europe. Philip Dawson. St Ry Jl—Oct. 12, 07. 16 figs. 7100 w.

Electrical Operation of the West Shore Railroad. St Ry Jl—Oct. 12, 07. 26 figs. [illegible] w.

General Features of the New York Central Electrification. St Ry Jl (Atlantic City Convention Number)—Oct. 12, 07. [illegible] w.

Single-Phase Electric Motive Power on the Rochester Division of the Erie Railroad. W. N. Smith. Eng News—Oct. 12, 07. 7 figs. [illegible] w. 20c.

Single-Phase Electric Traction on the Rochester Division of the Erie R. R. W. N. Smith. Eng News—Oct. 17, 07. 14 figs. 10,900 w. 20c. Describes alternating current system of electric traction upon a steam railroad to go into commercial operation.

The Field for Electricity on Steam Railways. Frederick Darlington. Ry Age—Oct. 18, 07. 1 fig. 5000 w. 20c.

The Heyland Cascade Single-Phase Railway System. H. M. Hobart. El Engg—Oct. 3, 07. 2 figs. 5500 w. 40c. Describes system in which induction motors without commutators are employed and a number of exceedingly important advantages thereby secured.

The Richmond & Chesapeake Railway. El Ry Rev—Oct. 19, 07. 8 figs. 2700 w. 20c. Describes a 15-mile single-phase road for passenger and freight traffic.

The Vienna-Baden Railway. Ry & Engg Rev—Oct. 12, 07. 8 figs. 2200 w. 20c. Describes a recently completed high-speed single-phase electric railway in Austria, connecting the cities of Vienna and Baden.

Power Generation and Distribution.

Distribution of Current to Trains on Electric Railways. Ry Engr—Oct., 07. 10 figs. 3100 w. 40c. 11. The Insulation of the Conductors.

Electric Practice of the New Haven Railroad. St Ry Jl—Oct. 12, 07. 8 figs. 7100 w.

Experience With a Grounded Neutral on the High-Tension System of the Interborough Rapid Transit Company. George I. Rhodes. Proc Am Inst. El Engrs—Sept., 07. 3 figs. 3500 w. 60c. Paper read before the Am. Inst. El. Engrs., New York, Oct. 11.

Line Construction for Interurban Electric Railways with Data on Costs.—I. E. P. Roberts and G. C. Gillette. El Tr Jl—Oct. 3, 07. 2 figs. 6500 w. 20c.

Long Island City Power Station of the Pennsylvania Railroad Company. — II. Engg—Oct. 18, 07. 13 figs. 5200 w. 40c.

Operating Features of the Fifty-ninth Street Station of the Interborough Rapid Transit Company. St Ry Jl—Oct. 12, 07. 7 figs. 4900 w.

Operating Features of the Long Island City Power Station of the Pennsylvania Tunnel and Terminal Railroad Co. St Ry Jl—Oct. 12, 07. 9 figs. 7200 w.

Operation of Electric Locomotives by the New Haven Railroad. St. Ry Jl—Oct. 12. 07. 5800 w.

Power Distribution System of the New York Central. St Ry Jl (Atlantic City Con Num.) Oct 12, 07 36 figs. 950 w

The Power Station and Practice of the West Jersey & Seashore Railroad. St Ry Jl Oct. 12, 07. 2 figs. 3500 w.

Power Station Practice of the New York Central. St Ry Jl (Atlantic City Convention Number)—Oct. 12, 07. 12 charts. 7100 w.

Recent Improvements in Control Apparatus for Railway Equipments. F. E. Case. St Ry Jl—Oct. 19, 07. 1400 w. 20c. Paper presented at the Atlantic City Convention of the Am. Street Interurban R. E. Assn.

Sub-Station Practice of the New York Central. St Ry Jl (Atlantic City Convention Number)—Oct. 12, 07. 5 figs. 5000 w.

The Distribution and Sub-Station System of the West Jersey and Seashore Railroad. St Ry Jl—Oct. 12, 07. 30 figs. 3500 w.

Rolling Stock.

All-Steel Passenger Cars. Hudson Companies. Am Engr & R R Jl—Oct., 07. 8 figs. 3100 w. 40c.

Electric Rolling Stock of the New York Central. St Ry Jl (Atlantic City Convention Number)—Oct. 12, 07. 2 figs. 7000 w.

Long Wheel-Base Trucks. R. L. Acland. El Engr—Sept. 27, 07. 3 figs. 3900 w. 40c. Paper read before the Municipal Tramways Assn., London.

Maintenance of Electric Rolling Stock of the Long Island Railroad. St Ry Jl—Oct. 12, 07. 34 figs. 3700 w.

Maintenance of Electric Rolling Stock on the New York Central. St Ry Jl (Atlantic City Convention Number)—Oct. 12, 07. 7000 w. 30c.

Maintenance of Electric Rolling Stock West Jersey & Seashore Railroad. St Ry Jl—Oct. 12, 07. 7 figs. 5200 w.

Pressed Steel Pay-As-You-Enter Cars in Montreal. St Ry Jl—Oct. 5, 07. 7 figs. 1600 w. 20c.

The New York Cars of the Pay-As-You-Enter Type. St Ry Jl—Oct. 26, 07. 5 figs. 1500 w. 20c.

Rolling Stock for the Washington, Baltimore & Annapolis Electric Railway. El Ry Rev—Oct. 12, 07. 4 figs. 3000 w. 20c.

Shops.

New Shops and Car Houses at Knoxville. St. Ry Jl—Oct. 5, 07. 16 figs. 3200 w. 20c. Describes buildings of fireproof construction well laid out for economical shop work.

Track.

Care of Electric Railway Tracks. George L. Wilson. Eng Rec—Oct. 19, 07. 3600 w. 20c. Paper read before the American Street and Interurban R. E. Assn.

Line and Track Service Plant, Brooklyn Rapid Transit Company. El Ry Rev—Oct. 5, 07. 4 figs. 2100 w. 20c.

Los Angeles Interurban and Pacific Electric Railways: Bridges and Culverts. El Ry Rev—Oct. 19, 07. 10 figs. 1300 w. 20c.

TECHNICAL LITERATURE

Vol. II. === DECEMBER, 1907 === No. 6

BUILDING A GREAT INDUSTRIAL WATERWAY*

THE CONSTRUCTION OF THE CAPE COD CANAL

By REED CARRADINE

CONDENSED FROM "AMERICAN INDUSTRIES"

Never before in the history of the United States has there been such activity, both by the Federal Government and the individual states, as well as by private corporations, in the development of waterways. The country in entering upon an era of canals never before equaled in either hemisphere, the effects of which are being felt equally in California and Massachusetts and from Minnesota to Texas, Louisiana and Florida.

The chief cause for this general interest in the development of the Nation's coastwise and interior waterways was the freight congestion of last winter, when whole communities in the Northwest were in the direst distress because the railroads could not find cars in which to haul coal to them, and farmers whose granaries were bursting with wheat were unable to purchase even the necessities of life because of the lack of cars in which to get their grain to market. Then it was that the people awoke. They realized that the continued prosperity of the Nation was jeopardized because of the demonstrated inability of the railroads to keep pace with industry and the result was that they swung with enthusiastic energy into the work of rehabilitating its rivers and of building canals.

President Roosevelt only recently completed a trip over the route of the proposed waterway from the Great Lakes to the Gulf, and declared his intention of recommending an appropriation for this work in his next message to Congress; Florida has let the contract for a canal from Jacksonville to Key West; a distance of 500 miles; a convention was held in Philadelphia on November 19th and 20th in the interest of the proposed inland waterway from Cape Cod to Jacksonville, and the routes for several other proposed inland channels have been surveyed and work will doubtless be begun in a short time.

The first and probably the most important link in this chain of waterways from Boston to Key West is the Cape Cod Canal, work on which was begun August 19th last when William Barclay Parsons, the chief engineer, turned the first shovelful of earth at a point midway between Buzzard's Bay and Barnstable Bay, the termini of the canal; since which time the work has been pushed with the utmost vigor consistent with the economic completion of an undertaking of this magnitude, and we are assured by Mr. Parsons that ships will be passing through this long needed canal by 1910.

It would be difficult to mention a great industrial enterprise which has been so long and so sorely needed as this canal or one which

*Through the courtesy of "American Industries," we are enabled to present the illustrations accompanying the original article.

will prove of incalculable benefit to such a large number of people or to so great a diversity of business, manufacturing and shipping interests of every description.

Few people have any conception of the magnitude of the traffic around Cape Cod; but some idea can be obtained from an inspection of the United States government lighthouse figures. These statistics show that in one year, that which ended on March 31, 1899, and whose record was about an average one, more than 30,000 vessels passed within sight of Handkerchief Shoal light-ship. It is conservatively estimated that during the same year other vessels which passed by in fog or at night, if added to this number, would augment the total by at least 10,000. About twenty per cent. of the vessels used steam. More than 23,000,000 tons register was shown, the average for steam vessels being 1,500 tons, and for sailing vessels 600 tons. When the increase in coastwise traffic, which will be a logical sequence of the opening of this waterway, is added to the number which now annually round the cape, and the passenger steamers and private yachts which will naturally be diverted from their present amphibious routes are included, it will readily be seen that no other canal in the world has within its attractive influence a volume of traffic that is at all comparable to that which this channel will command.

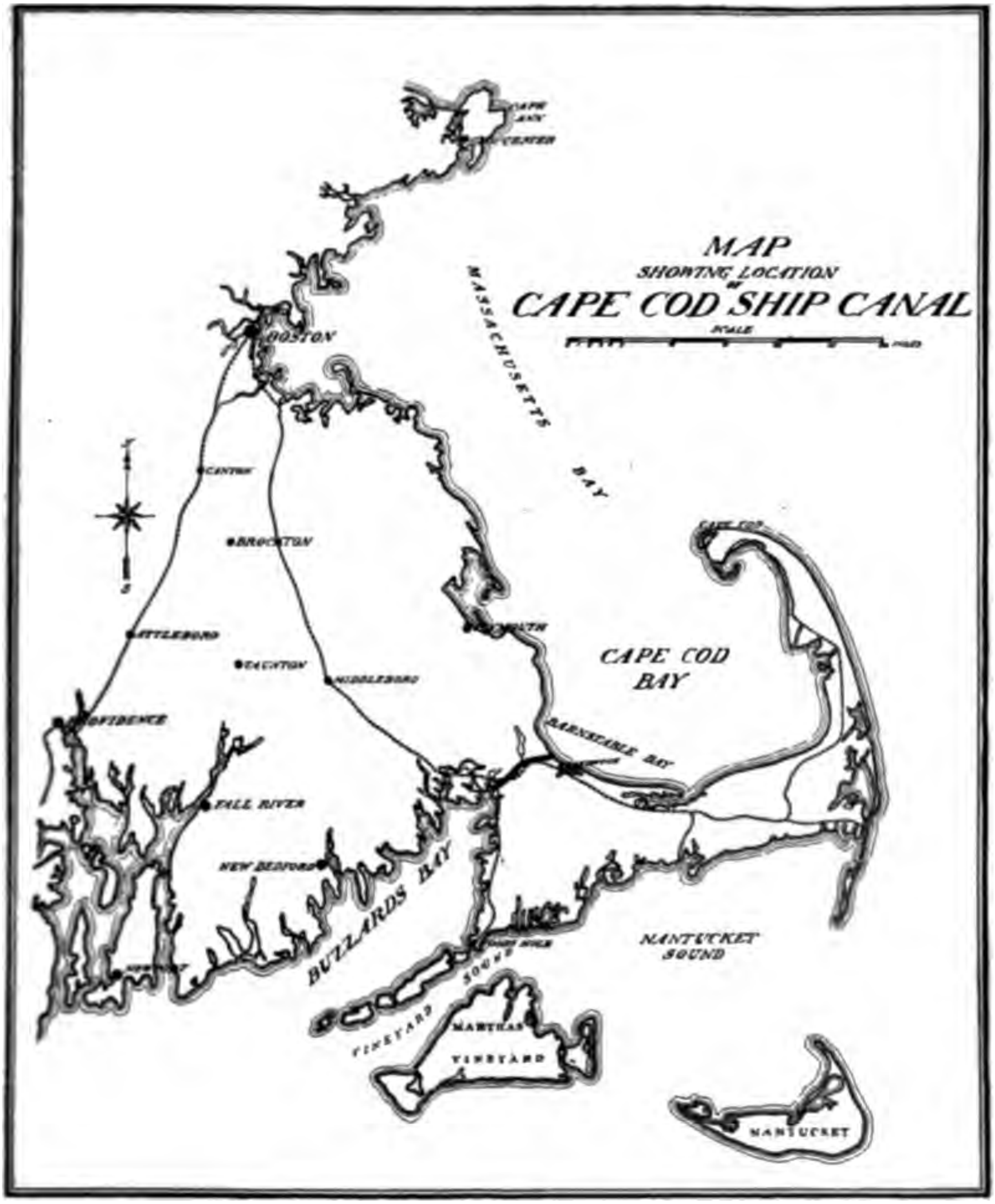
Were only 20,000,000 tons of the present traffic between Boston and New York to be diverted through the canal, an average toll of eight cents a ton would yield a gross annual income of $1,600,000.

For the year ending with June, 1907, 12,000,000 tons of coal alone were transported around the cape, while lumber, stone, cement, brick, ice and other classes of heavy freight, not taking into consideration high-class freight, such as is usually carried on passenger steamers, would total at least an equal number of tons. As against this it is estimated that the canal will require only $12,000,000 for its construction and $200,000 annually for its maintenance and operation.

From the dawn of New World history Cape Cod has been the graveyard of the Atlantic, 23 per cent. of the wrecks occurring on the eastern shore of the United States happening on this treacherous coast. Records of the United States government for twenty years present an exhibit most startling in its sacrifice of human lives and prodigal in its waste of property. An aggregate of 137 vessels went down off the cape during these two decades, carrying with them sixty-three lives, while the property loss reached $2,000,000. Nor was this an especially unfortunate period for seamen and cargoes on the shoals. Within less than four years more, twenty-seven additional lives were lost, twenty-eight vessels were wrecked and material wealth of more than a quarter of a million dollars disappeared beyond all hope of salvage, making a monthly property loss of nearly $7,000 and costing three lives and three vessels every two months. Nor is the peril of rounding the cape summed up in the loss of lives and vessels. Again the United States government reports show that for one hundred days each year vessels are fog-bound in the vicinity of Martha's Vineyard and Nantucket, the delays at these points ranging anywhere from one to ten days.

The saving of time as a result of shortening

[illegible] SHOVEL WORK ON THE CANAL



A COMPREHENSIVE MAP SHOWING THE CAPE COD CANAL ROUTE AND ITS ENVIRONMENTS.

the distance between Atlantic ports is by no means the least important item in connection with the building of this canal. Between New York and Boston there will be a gain of seventy-four miles over the Vineyard Sound route the shortest under present conditions and the one which is used by vessels of light draft), and 142 miles over the route outside of Nantucket. It will, moreover, have the further advantage of a comparatively inland and absolutely safe route, avoiding innumerable shoals which now render navigation hazardous in the extreme.

The great need for this canal has never been doubted, and its entire feasibility has never been questioned, because it presents no difficult engineering problems whatever. The soil to be excavated consists of sand and clay, and

the chosen route lies through a valley. The climate is equable and healthful, and the amount of money necessary to complete the canal is exceedingly small in this day of large undertakings, while the sum that will be required for its maintenance and operation is practically nothing.

It seems almost incomprehensible that in the course of more than two centuries an enterprise well within the meaning of a public utility failed to command the support of the Commonwealth of Massachusetts or the Congress of the United States, and all this while the nation's ever-increasing commerce paid an ever-increasing toll in lives, vessels and time to the treacherous shoals of Nantucket and the passage around the Cape. But it has remained for private capital to plan the waterway in order to earn the return upon investment which certainly awaits the owners of such a canal.

In June, 1899, former Representative De Witt Clinton Flanagan, a namesake of the man who built the Erie Canal, applied for and obtained a charter from the Massachusetts Legislature giving him the right to build a canal from Buzzard's Bay to Cape Cod of not less than 25 feet in depth, 100 feet wide at the bottom, and having a surface width of 200 feet. For several years thereafter he carried the project alone, successfully combating interests which were opposed to the building of the waterway, until eighteen months ago, when August Belmont became associated with him, and together they have brought matters to the present happy condition of affairs. Mr. William Barclay Parsons drew the plans, according to which the canal will be constructed, and John B. McDonald, who built New York's underground railway, will have personal charge of the construction work.

On June 27 last the contract for the building of the canal was awarded to the Cape Cod Construction Company, of which August Belmont is the president; Arthur L. Devens, vice-president; John B. McDonald, vice-president in charge of construction; William Barclay Parsons, chief engineer; John F. Buck, secretary and treasurer; and De Witt C. Flanagan, E. W. Lancaster and Dudley Pickham, directors. On August 19 Mr. Parsons turned the first shovelful of earth and the great undertaking was started fairly on its way. The illustrations which appear on this page show the inauguration of the work and the progress which has been made since. Four large hydraulic dredges have been ordered and will be in operation by next spring. These dredges will suck up the sand and convey it through pipes to any point desired within three miles of the spot where the dredge is located. The soil excavated will be utilized to fill in the Shusset Marshes, thus converting waste land into valuable real estate. In the meantime work will continue throughout the winter with steam shovels, flat cars and laborers armed with picks and shovels.

The canal, when completed, will be twelve miles long and will extend from Buzzard's Bay, at "Gray Gables," the summer residence of former President Grover Cleveland, to a point near the town of Sandwich, on Barnstable or Cape Cod Bay. It will be 160 feet at the bottom and 320 feet on the surface at the narrowest portion, and will have a depth of 25 feet at low water. At the western terminus a large steel bridge will be erected for the use of the New York, New Haven & Hartford Railroad, which will cross the canal at this point and parallel it on the south side to its eastern terminus. Here a large breakwater and artificial harbor will be built, which will afford a safe harbor for vessels of the deepest draft.

COMMENCEMENT OF WORK ON THE CAPE COD CANAL.

SHAFT SINKING BY THE FREEZING PROCESS

By SIDNEY F. WALKER

CONDENSED FROM "THE ENGINEERING AND MINING JOURNAL"

Sinking by the freezing process is gradually making its way. It has been somewhat largely employed in Germany and Belgium, where it has also been used for driving tunnels in railway work; and within the last few years two important sinkings have been carried out in the county of Durham, in the United Kingdom, one at Washington colliery, and the other at the Dawdon colliery, in the neighborhood of Seaham harbor.

At Dawdon it was the water from the sea which caused the great trouble in sinking, enormous quantities of water passing in through gullets in the magnesian limestone, the total quantity of water to be pumped before the freezing process was resorted to being 7,050 gals. per min.

In the United Kingdom and in Germany and Belgium, the great trouble with water-bearing strata usually arises in the loose quicksands that are sometimes met with. At Dawdon there was 92 ft. of yellow sand and 356 ft. of magnesian limestone, while at Washington colliery there was 41 ft. of clay sand lying on a gravel bed, with a bed of clay with boulders underneath, and 34 ft. of dry yellow sand above.

Principles of the Process.—The freezing process consists essentially in building a wall of ice around the shaft from the water from which the trouble arises, and the sand or other strata in which the water is inclosed. The ice wall consists of a hollow cylinder, completely inclosing the space in which the shaft is to be sunk, at such a distance that the process of sinking can be carried on with safety, and without damaging the ice wall. In the Washington sinking, the shaft was to be 14 ft. in diameter, and the ice wall was formed in a cylinder of a mean diameter of 20½ ft. At Dawdon the shaft was to be 20 ft. in diameter, and the holes for the freezing apparatus formed a cylinder 30 ft. in diameter.

The ice cylinder, when formed, must be sufficiently strong mechanically, to withstand all the strains and stresses that may be brought against it, both by the processes of sinking on the inside of the cylinder, and by the working of the ground, the motion of the water and any other forces that may be present on the outside. It must also be of sufficient thickness, and must be frozen to a sufficiently low temperature, to stand the constant attrition that will go on, owing to the convection currents that will be set up in the water surrounding the ice cylinder.

As the water from which the ice cylinder has been formed will necessarily be at a considerably higher temperature than the outer portion of the ice wall, there will be a continual passage of heat from the water to the surface of the ice wall, with a continual melting of a small quantity of the ice, followed by a continual motion of the water which has delivered the heat to the ice wall, its place being taken by the colder water behind.

The thickness of the ice wall will vary, according to the conditions present. It will necessarily be thicker with a deep sinking than with a shallow one. It will also necessarily be thicker with a shaft of larger diameter, such as that at Dawdon, than with the comparatively smaller diameter, as at Washington. At present no rule can be given as to the thickness of the wall, there are so many factors in the equation, so many of what mathematicians call independent variables.

The Surrounding Strata.—In addition to the questions of depth and diameter, there are also the questions of the surrounding strata, and of the strata below, which will materially modify the question of the thickness of the ice wall. At Washington colliery the wet sand to be frozen, as mentioned, rested upon a bed of clay, containing boulders varying in size from a pea to 3 ft. in diameter, and the German engineers who carried out the work, insisted upon sinking right through the clay, and right down to the yellow freestone which underlay the clay, as they stated that they had met with considerable difficulty in sinking through running sands in Germany, where

they did not carry the ice walls into a substantial stratum below.

In addition to freezing the water of which the ice wall is formed, the temperature of the sand, clay, limestone, or whatever the water may be held in, has also to be reduced to that of the ice formed from the water. As the freezing process is now carried out, the brine which circulates in the pipes to be described abstracts heat from the water surrounding them, and from the stratum that is held by the water, and carries it to the brine tank in which the evaporating coils are immersed, there delivers it to the evaporating coils, which in their turn carry it, by way of the compressor, or the absorber and generator, to the condenser, and thence to the cooling water.

Refrigeration Required.—When the depth and diameter and thickness of the ice wall to be formed are known, it is not a difficult calculation to find the quantity of heat that must be abstracted from it, and delivered to the cooling water of the condenser. In order to freeze the water it is necessary first to lower its temperature from whatever it may be, say 70° F., to the freezing point, in the neighborhood of 32° F. Then the water must be frozen, and when it is frozen, the temperature of the ice so formed must be lowered considerably below the freezing point.

Whenever ice is formed, whether by mechanical process, or as we say, naturally, unless the ice, after freezing, is reduced a considerable number of degrees below the actual freezing point, it does not remain in a stable condition; it is more or less "sloppy." Every little addition of heat, such as may arise from friction, in this case from the presence of water at a considerably higher temperature, and from other causes, raises the temperature of a small portion of the ice sufficiently for it to become liquid, and produces a soft condition.

The quantity of heat required to raise the temperature of 1 lb. of water increases very slightly as the temperature of the water increases, and vice versa.

Water also, which is impregnated with salts, as the water in the neighborhood of sinkings almost invariably is, has two properties. Its freezing point is lowered, and its specific heat is also lowered. For practical purposes, however, it will be sufficiently accurate to take the specific heat of the water in the strata to be taken as 1. The specific gravity of water in which salts are dissolved, is also increased, but for practical purposes again it will be sufficient to take it as 1, and to take the gallon of the water to be frozen as weighing 10 lbs.

Hence from every gallon of water to be frozen, assuming its normal temperature to be 70° F., 380 B.T.U. must be abstracted in order to bring the whole o fthe water to the a further 1,420 B.T.U. must be abstracted in order to bring the whole of the water to the frozen condition.

Every substance, it is well known, exists either in the gaseous, liquid, or solid condition, owing to the presence or absence of a certain definite quantity of heat. Thus, while to raise the temperature of 1 lb. of water 1° F. requires the expenditure of one heat unit, to convert the same pound of water into steam at the boiling point requires 966 B.T.U. at ordinary barometric pressure. Again, the latent heat of water, which enables it to maintain the liquid condition, is 142 B.T.U.

That is to say, after the water has been reduced to the freezing temperature, 142 B.T.U. must be abstracted from every pound or 1,420 units from every gallon, to reduce the water to the solid condition, ice. The specific heat of ice is only 0.5, as against water 1. Hence to lower the temperature of the ice from the freezing point to 0° F., or thereabouts, the practice usually followed in sinking by freezing, 16 B.T.U. must be abstracted from every pound of ice, or taking the calculation back to the water, 160 B.T.U. must be taken from every gallon.

Putting these figures together, 1,960, or roughly, 2,000 B.T.U. must be abstracted from every gallon of water present, that is to be converted into ice, in the ice wall that is to be formed.

This is, however, only a part of the heat that must be abstracted. As explained, the temperature of the sand, the clay, the limestone, or whatever the water may be held in, must be lowered to the same temperature, in this case taken as 0° F., to which the water that is imprisoned in it is reduced.

When the dimensions of the ice wall are known, it is a simple calculation to find its cubic content, and then taking 63% of this to be sand, where that is the substance in which the water is held, and 37% of water, and converting these by means of their respective specific gravities into pounds, or in the case of water, into gallons, multiplying the gallons of water by 2,000 will give the number of heat units that must be abstracted to reduce

water to ice at 0° F. The number of units to reduce the sand or other sub- e to the same temperature will be found ıultiplying the weight in pounds by the fic heat, and by 70, assuming the tem- :ure of the sand to have been originally F.

intenance of Frozen Walls.—This calcu- n, which may be put into a formula that give the total number of heat units that be abstracted from the stratum and the r held in it, in order that the ice wall be formed. It will be wise, as in all ıeering work, to allow a liberal margin ınforeseen contingencies, the margin be- ıs usual allowed in the refrigerating plant.

addition to the above, if the ice wall is :main intact, while the sinking proceeds, must be continually removed as it is ered to it. If left to itself, the ice wall slowly melt away, owing to the action ıe water, as explained above, and to con- on of heat from the neighboring strata. ıe quantity of heat that will be delivered ıe ice wall, may be determined approxi- ly from Peclet's formula. It depends tly upon the surface exposed, and upon difference of temperature between the ice of the ice wall and the substances in ıct with it. Again a liberal allowance ld be made in the plant that is designed ıaintain the temperature of the ice wall ° F., but the plant that is employed to :e the ice wall, should in every case be than sufficient to maintain it.

ɔw the Heat is Abstracted.—A ring of cal pipes is fixed in the ground contain- the water to be frozen, and carried from the surface. In practice the holes are from the surface to the water-bearing a, and through them to the depth to h it is decided to carry the ice wall. The s are placed usually from 3 to 4 ft. apart, number varying with the diameter of the ylinder to be formed.

ıe actual freezing arrangement consists wo concentric tubes, which must stand in ground absolutely vertical. The bottom of the outer tube is closed, and the bot- end of the inner tube is sometimes fitted a strainer or something of the kind, to ent the passage of grit, etc. The inner is usually from 1 to 1¼ ins. in diameter, ırger with very deep sinkings. The size ıe outer tube will vary with the depth of ice cylinder, its thickness and diameter. At Washington the outer tubes were 4 ins. in diameter, and at Dawdon 5 ins.

The cooling action of the pipes in which the cold brine is circulating depends directly upon the surface of the pipe exposed to the stratum, and the water contained in it; hence the deeper the sinking, etc., the larger the tube.

Fixing the tubes in an absolutely vertical position presents the greatest difficulty of the process. Holes are drilled where rock or clay has to be passed through, or bored with a sharp-edged tube, and a sand pump, where sand is passed through, the holes being considerably larger in diameter than the outer freezing tubes to be employed. At Washington the holes were 6 ins. in diameter, and at Dawdon they ranged from 9⅞ ins. at the top to 6¼ ins. at the bottom.

The holes, when drilled or bored, are lined with guide tubes, practically filling the bore hole, and inside of this the outer freezing tubes are first fixed, and then the inner tubes. Through a considerable depth of strata not required to be frozen, as at Dawdon, it is the practice of the German engineers who carried out the sinking at that colliery, to fix a third set of tubes between the inner and outer tubes, for the depth that is not required to be frozen. The third set of tubes is connected to the outer tubes, and it is arranged that the brine flows between the inner and the middle tubes, leaving an air space between the middle tube and the outer, and so to a certain extent insulating the strata and the shaft work that may have been done above the stratum to be frozen. The object of this arrangement is two-fold. It lessens the work the brine and therefore the compressors have to perform, and it avoids the exposure of the shaft work that is not to be frozen, to the very low temperature attained in the other strata.

The Power Required.—A cold-storage plant is rated as a one-ton plant, a two-ton plant, etc., according to the quantity of refrigeration it is capable of accomplishing in twenty-four hours. A one-ton plant is supposed to be capable of performing the equivalent refrigeration to that that would be produced by the melting of one ton of ice, at 32° F. in 24 hours. The American ton is 2,000 lbs., while the British ton is 2,240 lbs. Hence the American ice ton is 284,000 B.T.U., and the British is 318,080 B.T.U.

When ice is to be formed, it is usual to divide the ratings by two. Thus a one-ton

machine should do the same work in cooling the air of a cold store, as would be done by the melting of one ton of ice, but it will not produce one ton of ice. In the present matter it will be wiser to allow even a larger margin, and for this reason. Artificially made ice is usually reduced to a temperature of from 15° F. to 17° F., whereas the ice wall in the present case will be at only a few degrees F., and the lower the temperature to which it is reduced, the better it will stand.

To find the size of plant required for performing the operation of freezing an ice wall, the cubical contents of the ice wall have to be calculated, and the heat units to be abstracted respectively from the water and the sand or rocks taken, this being the total work to be done.

The whole of the freezing can be carried out within certain limits, in as long or as short a time as the engineer chooses, the smaller the time in which the freezing is to take place, the larger the plant required for the purpose.

For ammonia, the rule for the compressor is that for each ton of refrigeration, or each half ton of actual ice-making capacity, the compressor should be able to transfer $4\frac{1}{2}$ cu. ft. of gas per minute from the expansion coils to the condensing coils, and the capacity of any given ammonia compressor may be found from the formula:

$$C = P\ L\ N \div 7{,}500,$$

where C is the capacity in tons, P is the area of the piston in square inches, L the length of the stroke in inches, and N the number of single strokes per minute.

Or per contra the size of the compressor required may be found from the formula:

$$P = 7{,}500\ C \div L\ N.$$

Refrigeration compressors work at a very much lower piston speed than modern steam engines, 200 ft. per minute or thereabouts.

Cooling Water.—The above figures are on the supposition that the cooling water for the condenser is at the temperature of 70° F. For every 5° the temperature of the cooling water exceeds 70° F., the capacity of the compressor is reduced by 1%, and for every 5° below that temperature it is increased 1%. The quantity of cooling water required in the condenser will vary again with its initial and final temperatures. At 50° F., with atmospheric condensers, it is usual to allow ½ gal. per min., the quantity increasing with the initial temperature to 2 gals. per min. at 85° F., the cooling water being supposed to leave the condenser at a temperature of 95° F. Where there is plenty of cooling water, it is wiser to use a larger quantity, and not to allow the temperature to rise much. For submerged condensers the quantity of water required will be from 20 to 25% more than with atmospheric condensers. In the submerged condenser, the water has to do the whole of the work, while the evaporation by the atmosphere does a portion of it with atmospheric condensers.

The brine tanks are usually arranged to have 60 cu. ft. of brine capacity per ton of refrigeration, that is, per half ton of ice-making capacity. The length of the evaporating coils in the brine tanks will again vary with the size of the pipes. The cooling effect depends directly upon the surface exposed to the brine, and a smaller length of a larger pipe can be employed where it is convenient to do so. The usual rule is for 1-in. pipe, a length of 150 ft. per ton of refrigeration, and for a 2-in. pipe, 90 ft.

NOTES ON INSULATION AND INSULATION TESTING*

By S. M. HILLS and T. GERMANN

FROM THE "ELECTRICAL ENGINEER" (LONDON)

A substance insulates because it is possessed of three distinct properties: firstly, the ability to stand mechanical and electrical stresses due to the voltage used; secondly, a conductivity such that but a negligibly small current can flow through it and leak away; thirdly, the power to resist chemical action that may be set up by application of the voltage. There is no direct relation between the breakdown e.m.f. and the ohmic resistance of an insulator. A low ohmic resistance usually means a low breakdown test, but the converse is not always true.

A good insulator should fulfil the following

*From a paper read before the Northampton Institute Engineering Society.

general requirements: (1) high disruptive strength; (2) good ohmic resistance; (3) physical properties should remain permanent over a wide range of temperature; (4) must be non-volatile and non-hygroscopic; (5) resist the action of water, acids, and alkalies; (6) fireproof.

No single substance fulfils all these requirements, and various mixtures have been devised in an attempt to produce an insulator possessing the required properties. The density, and, therefore, the molecular composition of the various components, of the mixture is different, and the particles or cells of which they may be conceived as being built up of can move more freely in some than in others. Since the electrical displacement varies directly with the density, the effect of a mixture is to cause an unequal distribution of pressure in the dielectric. A large number of insulation troubles may be attributed to this phenomenon.

Line Insulation.—In high-voltage distribution, the insulation of the line is a very important matter. There are two substances to choose from—namely, porcelain and glass. Good samples of either will give excellent results up to 5,000 volts, but beyond this figure considerable leakage occurs. Glass often permits of leakage when new, and ages very badly; the surface becomes roughened, moisture and dirt collect until the surface is found to be a tolerably good conductor. Cheap porcelain is often extremely hygroscopic, some makes absorbing 1 to 2% of moisture. Porcelain for insulating purposes should absorb no moisture and show a brilliant vitreous fracture, which will give no flowing stain with ink. Glass is homogeneous throughout its thickness, but with porcelain it is often found that once the glaze is damaged a porous and practically non-insulating porcelain is revealed. The best substance to use is a thoroughly vitrified porcelain, in which the ordinary glaze is replaced by an actual fusing of the material itself. It is strong, tough, and non-hygroscopic, has very high insulating properties, the surface does not weather, and the insulation is practically permanent. The insulator should be so designed that the extent of surface is as long and narrow as is practicable; also the surface must be initially and continuously highly insulating.

Oils.—With the increased use of high-voltage distribution a larger number of oil-cooled transformers and oil switches are required, and, therefore, the question of insulating oils has received more attention. Each manufacturer has his own pet specification, but the following contains the conditions required in an average specification: (1) the oil should be a pure mineral oil, obtained by the fractional distillation of petroleum, unmixed with any other substance, and without subsequent chemical treatment; (2) flash test must not be less than 180°; (3) evaporation not greater than 2% after heating for eight hours at 100° C.; (4) must not contain moisture, acid, alkali, or sulphur; (5) must be as clear as possible, fluid, and free from particles of metallic nature. There are two main methods employed in testing the dielectric strength of the oil—namely: (1) between two spheres submerged in the oil and placed ½ in. apart; (2) between two needle points placed ½ in. apart. The latter method gives a lower value than the former, and since in a transformer or switch many sharp edges, if not points, are met with, the authors favor the use of method 2.

Varnishes, when used in the preparation of insulation, are usually impregnated on cloth, paper, etc. This forms an insulator, the density and electrical displacement of which is not the same in all parts—a very undesirable state of affairs. It is advisable to test the dielectric strength of the varnish when impregnated on paper, at various densities, in order to endeavor to obtain an insulator of somewhat uniform density. The highest dielectric strength will not be obtained by using the highest density varnish, unless the density of the neat varnish happens to be best suited for passing into the pores of the paper.

Ageing and Heating.—Insulation often rapidly deteriorates with age, and it is necessary to store samples of insulation and test them after they have been stored for two or three months. The deterioration is probably due to atmospheric and drying effects, also to the mechanical stresses produced by the rapid alternation of the voltaic stress. Insulation is a bad conductor of electricity, and, therefore, as would be expected, it is a bad conductor of heat—a property which accounts to a large extent for its deterioration with age. The higher the temperature of the insulation the lower the dielectric strength.

Marble.—Marble is largely used for switchboards, and though preferable to slate on account of its absence from metallic veins, it is not an ideal switchboard material. Marble is one of that class of substances which are always cold, consequently it rapidly condenses moisture, which on a switchboard causes sur-

face leakage. The mechanical properties vary inversely with the electrical properties. The specific gravity has a considerable effect on the properties—e. g.: (1) the greater the specific gravity the lower the absorption of moisture; (2) the greater the specific gravity the greater the crushing stress; (3) the greater the specific gravity the lower the breakdown voltage.

Conclusion.—Practically speaking, there is no piece of electrical machinery in which some insulation is not used, yet but little is known about the subject, nor is the requisite amount of importance assigned to it. Doubtless many of the large firms have a considerable amount of knowledge on the subject, but it is so jealously guarded that the average electrical engineer stands but little chance of obtaining it. Insulation is affected by so many things that testing is a matter of great difficulty, and widely different results are obtained, the reason or reasons for this not being definitely known. It is, therefore, imperative that great care should be taken to make tests, which are to be used for comparative purposes, under precisely similar conditions. The study and improvement of insulation demands the attention of the scientific electrician and chemist, not the practical engineer, who considers insulation to be fulfilled by wrapping tape round a conductor.

THE MANUFACTURE OF BESSEMER STEEL RAILS*

By FRANKLIN E. ABBOTT

This description will be limited to the making of Bessemer steel for the manufacture of rails as now used. All reference to rolling mills will imply the mills of the Lackawanna Steel Co. in this immediate vicinity. Ores used at the Buffalo steel plant come from Pennsylvania, northern Michigan, Wisconsin and Minnesota, with the northern ores in predominance. Statistics of iron ore mining show that fully two-thirds of all rail steel made in the United States come from Mesaba ores.

Making steel by the direct process consists in taking molten iron direct from the blast furnaces to the steel plant and continuing it through the process of steel making without ever becoming solidified till finished. The iron is taken from the furnaces in ladles holding about 20 tons, from which it is poured into a large mixer holding about 200 tons. The object of the mixer is to make a better average composition of iron, and hence a more uniform grade of steel. From this large vessel, or mixer, the iron is drawn into a ladle holding about 10 tons, and from this charged into the converter, when the process of steel making begins.

The blowing of the iron in the converters sets up reactions which result in decarbonization, and also burns out silicon and manganese, but sulphur and phosphorus originally in the iron will remain after the blowing, and in slightly increased percentage, owing to reduction of the original volume by oxidation. The blowing takes from 10 to 20 minutes, depending on the quality of iron, and a skilful operator can tell when the metal has been sufficiently burned out by the color and dropping of the flame, when the vessel is immediately returned to a horizontal position. The contents of the vessel at this stage are nearly pure iron.

While the molten iron is still in the vessel, a quantity of other molten metal called spiegeleisen, containing a known quantity of iron, carbon, manganese and silicon, is poured into the vessel and is immediately diffused through the whole mass; thus iron is changed into what is known as Bessemer steel. The steel is then poured from the vessel into a ladle, and from that tapped out into ingot molds in which it is left to solidify.

The ingot molds are cast-iron boxes, open at both ends, averaging about 18 ins. square, but tapering outwardly toward the base. The ingots are cast with these molds standing upright on heavy cast-iron table cars, the car tops serving as bottoms to the molds. They [illegible] then moved forward on these cars from [illegible] steel plant to the stripper. The stripper

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*From a paper read before Central Railway [illegible] falo, N. Y., Nov. 8, 1907.

ts of a powerful horizontal electrical , equipped with a combination of lifters plunger. The ingot molds are grappled ormous links automatically hooked into or lugs at the end of the molds, made hat purpose, and as the ingot mold is l the plunger comes down, forcing the from the mold through the open bottom, g it standing upright on its own base e car. With the ingot thus cast and the stripped from it, the process of steel g is completed.

e red-hot ingots are then forwarded, still ing on the same iron cars, to the rail where they are deposited in reheating ces called "soaking pits" and left there rought to proper temperature for roll- The placing of ingots in the soaking pits stantially the beginning of the rail mak- But before passing to that step in the de- ion it will be of interest to understand ell as possible the behavior of the steel what takes place when it passes from a l to a solid state.

en the liquid or molten metal comes in ct with the cold iron of the mold, it im- tely freezes at the sides and base and ally toward the center. The interior is st to cool, and the part of that last to will be at the top. The wide contraction the metal undergoes in passing from n to a solid state makes a very consider- reduction or shrinkage in its volume. As op of the ingot is the last to solidify, the ing in of the mass will concentrate at that , and there is formed a cavity or honey- ed part, extending a few inches down. opening or unsoundness at the top of ngot is known as piping.

other peculiarity that develops when passes from liquid to solid is segregation me of its constituent elements, especially n, sulphur and phosphorus. The term gation when used in connection with the llurgical characteristics of molten steel be understood as the drawing away from part of the mass to another of such ele- s as will separate before the steel freezes comes solid.

gregation apparently proceeds in the same that the steel solidifies. It works from uter parts toward the center, and there be the greatest concentration of the se- ted elements at the top of the ingot e the metal is last to cool. There is found is part not only the piping and spongy , but the part of the steel made inferior by an overload of carbon and probably manganese and also excessive sulphur and phosphorus. This inferior steel is discarded, as will be seen further along.

Keeping in mind, then, the shape and condition of the steel in the ingot, we will take up the second step, that of making ingots into rails. As already noted, the ingots are placed in the soaking pits, always in a vertical position, where they remain from 90 to 150 minutes, in order to be brought to proper temperature for rolling.

This heat treatment in the soaking pits results in lowering the temperature at the center of the ingots, which may at time of charging be nearly fluid, and raising the temperature of the outer part, which at the same time may be solid and reduced to cherry red. The whole mass is thus brought close to a uniform and approximately plastic condition, which makes it fit for the rolling process.

The reheated ingot is then taken from the pit, placed on an electric conveyer and rushed forward to the mill, where it is turned down on its side preparatory to entering the rolls. This is the first and only time an ingot lies in a horizontal position during the whole process of making and reheating the steel. It may be well to note here the great advantage gained by both makers and users of steel rails in this modern practice of always keeping ingots in a vertical position, from the time they are cast till the metal has been brought to proper consistency for rolling.

In nearly all specifications for steel rails there is a short clause which reads about as follows: "No bled ingots shall be used." This restriction, so much needed in old methods, is of little or no account at the present time.

In the early days of rail making, it was the practice to throw ingots on their sides as soon as they were taken from the molds, and, in fact, they were kept in that position in the reheating furnaces. If, by chance, the surface crust at the ends should break open, the fluid metal at the center of the mass would bleed out, leaving a hole which would almost certainly result in piped rails.

The longer time given under the present practice for the metal to solidfy in the molds, and always keeping the ingots in a vertical position in the reheating furnaces, practically eliminates all possibilities of any bleeding, and in a corresponding degree makes a protection against getting piped rails in the product.

When the ingot is turned down on its sides for the first time, it enters the blooming rolls.

The first two passes are through two separate sets of rolls of large diameter, operated by powerful engines. The motion is slow, and the reduction heavy. It then moves forward to the next set of rolls, where four passes are made and a bloom about eight inches by eight inches, 20 to 22 ft. long is completed.

In these shapes, the size of the bar is reduced sufficiently so that the ends can be sheared off. Enough metal is cut from the end coming from the top of the ingot to remove all traces of piping or spongy steel, and also removes the part containing greatest amount of segregation. From the other end, coming from the bottom of the ingot, enough is cut off to make the end face square and solid. After the shearing, the bloom is conveyed to the roughing rolls where in four passes a rough form of the rail section is worked out. From there the bar goes to the finishing rolls, making four more passes, thence moved sidewise across the mill floor to the last finishing pass, where the rail section is finally completed to the minute refinement of its detailed dimensions.

The block of steel which started at the other end of the mill, about 18 ins. square and 50 ins. long, has now become a rail with a sectional area six or seven square inches and 175 ft. in length. All this change has been made in an interval of eight to nine minutes.

In a two-high mill, such as the one referred to in this paper, the ingot is continued throughout the entire rolling process in one piece, and finally a single length is furnished equal to four or five 33-ft. rails. The long rail is carried from the last finishing pass to the hot saw, where it is cut into standard lengths, according to order, cutting one rail at a time, thence through the cambering rolls to the cooling beds, where the rails are left till brought to the temperature of the atmosphere, or about 70 degrees.

In passing through the cambering rolls the rails are forced into a curvature with the head arching upwardly. That is to say, if the rail, immediately after coming out of these rolls, were made to rest on its base, or in the trackman's parlance, "work ways," the ends would be low. From this shape it warps first to the opposite curvature, bringing the ends high, then back toward the first shape and finally drawing back again in the final cooling, leaving the rail, when resting freely, on its base with a back sweep or the ends up.

The effort on part of the mill superintendent is to regulate the cambering rails will cool as nearly straight as practicable, but as absolute straightness is almost impossible to attain, they are preferably brought, when cold, to a slight back sweep, as already described.

There are two reasons for having rails at their normally cold temperature with back sweep rather than head sweep, if they do not come out perfectly straight: First, the cold straightening work will be done mainly on the base, thereby escaping the danger of indentations from gagging iron on the running surface of the head. Second, the internal stresses left in the rail when it becomes cold, tending to draw the ends upward, even after it is cold straightened, will help to hold the joints up and maintain better track surface when the rails are put into use.

The rails pass from the cooling beds over live rolls, by which they are distributed to the presses where they are straightened, drilled, finished and inspected, thence they are carried down through the mill to the loading sheds and finally loaded on cars.

This completes a general outline description as to how rails are made, but it may be of interest to return to some points along the process of rail making where greatest difficulties are encountered.

When the spiegeleisen is poured into the purified iron in the vessel just after the blow, necessary ingredients are introduced to make it hard, elastic and ductile.

Chemical analyses of average Bessemer rail steel as made at present for heavy rails run about as follows:

	Per cent.
Carbon	.50
Phosphorus	.10
Sulphur	.08
Silicon	.12
Manganese	1.00
Iron	98.20
	100.00

The quantity of carbon can be controlled by the grade of spiegel used. The makers and users of rails are not exactly agreed as to what the limits in carbon should be. The users have been inclined to increase carbon content somewhat faster in proportion than the increase in weight of rails. When a 70-lb. rail was regarded as a heavy section, carbon, in the steel, ran from .35 to .40, but when the weights of rails reached 100 lbs. per yard, .60% carbon was called for, and in some cases the upper limit was fixed at .65%. The higher

on steel, 55% to 65%, was also specified ighter rails such as 80-lb. and 85-lb. per . The 80-lb. rail was an increase in ht of only about 14% over the 70-lb., 58% carbon often called for in this weight was an increase of fully 45% of this ele- over the lighter section. It can be seen hardening properties were raised entirely of proportion with the increased weight, the apparent consequence was a less sat- tory rail in the heavier section.

e reason for raising the carbon was to get elasticity and better wear, which in a ee was obtained, but with it came more res from breakage. It was then proposed specified on part of the users that phos- us should be lowered about 15%, making limit not to exceed .085%. This proposi- seemed entirely consistent from a metal- cal and theoretical standpoint, but prac- ly it cannot be obtained because of the ore itions.

is estimated that the available .085 phos- us Bessemer ores in the United States are ively small.

all the rail mills in this country were to rtake to fill, from American ores, the an- requirement of about 3,000,000 tons un- .085 phosphorus specifications for Besse- rail steel, that grade ore would be ex- ted before provisions could be made to the yearly demand for rails made by any r process.

open hearth steel is to succeed Bessemer, ll take a term of years and the expendi- of an enormous sum of money to build aces enough to provide the steel needed rails alone. Before this could be accom- ed it is more than probable that the .085 phorus Bessemer ores would run out, and an inadequate production of open hearth , the railroads would have to either get with a short supply or import the ton- lacking. In the event of such sources not able to keep pace with the demands, only alternative would be to take a grade essemer steel far inferior in wearing qual- to what they are now getting.

avoid this apparent short cut to the end od-quality Bessemer rail steel the makers t that the phosphorus limit shall be left has been for a number of years past, at , and a somewhat modified carbon content sed.

is entirely practicable to use enough car- with .10% phosphorus ores to make per- y sound, safe and serviceable Bessemer steel, and with that limit accepted, the manufacturers will be able to produce good-quality Bessemer steel rails for many years to come.

The wear of the heavier section rails has not been all that the users expected, even with the proportionally higher carbon, and they are loath to make any recession in this hardening element, fearing that by so doing there will still be greater loss from rapid wear. But the question of safety must have first consideration, and neither the makers nor users of rails will be justified in adding hardening properties, to get increased service that will place the material anywhere near the danger line of breakage.

So the question of carbon and phosphorus content that shall be used in Bessemer steel for rails is not fully and definitely settled. The phosphorus limit is substantially fixed by conditions. The carbon limit to correspond is likely to be fixed by more experience. There is a strong probability, however, that harder steel may be used if the shape of the rails is changed. How this may be brought about will be considered further on.

The next element in order in the steel composition is sulphur. This is of little consequence to the user of rails. Its effect is to make hot steel dry, or what is called "hot short," and liable to pull apart, making flaws on the surface of rolled shapes. A limit of .10% can be handled very well, but it is always to the interest of the manufacturer that it should be lower.

Silicon has a quieting influence in molten steel when it is settling and cooling in the molds and makes it dense when cold. A limit of .20% is generally stated in specifications.

The quantity of manganese in rail steel will run from .80 per cent. to 1.10 per cent. Its effect is to make the hot steel tougher, overcoming some of the bad effects of sulphur, and thereby better adapted to rolling. It also makes the steel harder and better for wear, but if the quantity exceeds very much the upper limit noted it is liable to lead to brittleness.

Another clause in standard rail specifications that is a source of some contention between makers and buyers of rails, reads as follows: "Sufficient material shall be discarded from the top of the ingot to insure sound rails." Under that agreement the buyers of rails can get, and do get, perfectly sound steel. The interpretation of the term sound in this case means entirely free from piping or spongy metal.

Sound steel rails of standard composition are perfectly safe to use, and when the railroad companies have exercised their rights given by the specifications in their inspection at the mills, while rails are being made, and thereby obtained sound rails, they have done their whole duty toward themselves and their patrons, whose safety and welfare they are bound to protect.

But the question arises why do the railroad people, or so many of them, come up with a demand for more discard, in some instances asking for a fixed amount not less than 25% of the whole ingot. It is not a question of safety, but one of service. Under present specifications, the rail mills must deliver to the railroads safe rails, that is to say, free from the danger that comes from piping. They are obtained by shearing from the top of the ingot sufficient material to insure sound steel.

Then what would the railroads gain by doubling the discard if 25% should amount to that increase? They might get a larger percentage of better wearing rails than they now receive, but the gain would be purely in an economical sense, and not in one of safety. Therefore, the question of more discard after enough has been made to insure sound and safe rails is purely a commercial one, and can be disposed of between the railroads and the steel companies without giving cause for any anxiety on part of the traveling public.

In addition to the discard sheared off the bloom, a crop end is cut off the long rail when it is finished, taken from the end toward the top of the ingot. This is about six feet long and is used for a drop test. One such test piece is taken from every blow of steel. It is placed on steel wedge-shaped bearings, three to four feet apart, and struck with a 2,000-lb. weight, falling 15 feet to 22 feet (depending on size of rail tested). The deflection of the test piece under this drop is carefully noted and made a part of the inspection records. If the test piece breaks under the drop, all rails from the blow represented by that test must be discarded.

This is the most satisfactory proof of the quality and strength of the rails that can be used. If the steel is brittle it will be discovered by the character of the break. If piped, that condition can be seen in the fracture and will determine at once whether or not sufficient discard has been made at the shears to insure sound steel. If the metal is very soft it will show by excessive deflection. It can be seen, therefore, that the drop test throws out many safeguards against passing defective or inferior material.

Another difficult part in the making of steel rails is in the section. In the first place, it has to be very close to mathematically correct. A finished rail is a simple looking thing when it is made, but there are a good many dimensions besides the length to take into account in getting it through the mill in proper shape. The ordinary rail section is made up of 17 separate and distinct dimensions, nine of which are duplicated, making a total of 26 to be kept in order and held in their respective places when the rolling is under way.

The section is continually checked during the process of rolling. This is done by a steel template made to exact dimensions of one-half the rail divided by its vertical axis. The rail section is tested on both sides by the same template, and therefore each half is as nearly like the other as is possible to make it. In checking rail sections, the inspector has to guard against either over or under size, and always strives to maintain perfect symmetry. In this detail a difference of 1-64 inch cannot be ignored and the wonder is how such ponderous and coarse machinery as constitutes a rolling mill can be so nicely adjusted as to accomplish such fine results. It is not easily done, and it should be remembered that the turning or shaping of rolls and the manipulation of steel through them when rolling is under way, is the most intricate part of the rail-making process.

Cambering of the rails is made necessary to counteract the warping that takes place in cooling. The warping is due mainly to the shape of the section, and the rail is rarely perfectly straight when cold. Whatever warp or crook that may be left in must be taken out by cold straightening. This is done in a press under a slow-motion plunger by applying pressure on the rail centrally between bearings 42 inches apart. The arrangement of this press has lately become part of a general specification, and for that reason should receive some notice in this connection.

It is pretty generally conceded by both rail makers and users that the strain and torture that rails have to endure in cold straightening are the most severe and most objectionable work in the whole manufacturing and finishing process. The impossibility of taking a bend or kink out of a rail without straining it beyond its sectional elastic limit makes the nece [illegible] ing up internal stresses, working

at cross purposes with the normally cold tension of the steel unavoidable. To what extent these may be harmful to the rail after it is put into service cannot be definitely determined, but it is only reasonable to infer that they have some effect.

THE DETROIT RIVER TUNNEL

CONDENSED FROM "ENGINEERING NEWS"

One of the most novel and interesting tunnel works now in progress is that of the Michigan Central R. R. tunnel under the Detroit River, to effect a direct connection with its Canadian lines and to avoid the present delay and inconvenience of the car-ferry service for transferring trains across the river.

DETROIT RIVER TUNNEL. FIRST SECTION READY FOR SINKING.

The work is now well under way, and the recent commencement of the river section makes a description of the work appropriate at this time. The special feature of the work is in the river section, which will be half a mile long. This is being formed by sinking steel shells in a dredged trench (as described below), so that there is no actual tunnelling under the river. The river work and the approach tunnels are all in stiff blue clay. This is firm and solid, with few pockets or water seams, as shown by the test borings. It is easily excavated, but requires heavy timbering to resist the pressure upon the shafts and drifts.

The river section of the Detroit River tunnel will be 2,620 ft. long between the ends of arch construction from the shore shafts, and is being built on the new and interesting method above noted. In brief, this consists of dredging a trench across the river, and laying a steel and concrete grillage at intervals marking the joining of the tunnel sections. Steel hulls or sections in lengths of about 262 ft. each will then be sunk upon this foundation. Each shell will form a portion of the twin tubes, with the ends temporarily closed by bulkheads. As each is deposited in place, concrete is filled in beneath and around it, and the joints are made as described below. When a few of the sections are in place, some of the bulkheads will be removed, the water pumped out and a 20-in. concrete lining put in each tube, so that in fact the steel shell is simply the form for a massive concrete tunnel. The method was adopted to save time and cost as compared with the usual methods of subaqueous tunneling. The difficulties to be encountered, however, are considerable, especially in view of the depth of water and the constant traffic in the river. The company is authorized by the

War Department to obstruct a width of 600 ft. of the channel when required.

The depth of water is about 50 ft. in the main channel, and the trench has to be dredged to a depth of 30 to 50 ft. in the river bed. The bottom width of this trench is about 48 ft., and the side slopes are found to stand well at 1 on 2. The material is a stiff blue clay. A dipper dredge was tried for excavating to a depth of 60 ft. below water, and worked well as far as the actual dredging was concerned, but the machine was not built for such heavy work and the largest spuds that could be used would not stand the pressure and snapped off when the bucket was making a heavy cut. The work is now being done with a dredge having a 60-ft. steel boom carrying a 3-yd. clamshell bucket.

Each shell consists of two cylindrical tubes 23 ft. 4 ins. diameter and 26 ft. 4 ins. c. to c., enclosed in transverse rectangular diaphragms 55 ft. 8 ins. long and 31 ft. deep, spaced 12 ft. c. to c. These diaphragms rest upon the I-beams of the foundation grillage. The total launching weight was about 600 tons. Four cylindrical steel tanks, 10 x 30 ft., were secured to the top by heavy bands, to furnish the desired buoyancy in sinking and adjusting the hull to its final position. These are removed later and used on other sections.

The first section was successfully sunk on Oct. 1, 1907. This was at the Detroit shore end. It was held in place only by cables, but these were led to the drums of a hoisting engine on shore, so that the shell could be adjusted as the work progressed. The concreting scow was held by its spuds close alongside the shell. Rubber hose attached to the two tubes (whose ends were closed by air-tight timber bulkheads) and to the four tanks were led to air pumps on the scow. From the shore end of each tube rises a 24-in. stack or manhole, 30 ft. high, and fitted with air pipes and valves. Over the center line of the northern tube was a steel column, having the faces painted in red and white checker marks to serve as a leveling pole in determining the elevation. At the bottom of each of the four bulkheads was an 18-in. valve operated by a stem with a hand-wheel on a platform bolted to the face of the bulkhead. A man was stationed at each platform, and at a whistle signal the valves were opened simultaneously. The sinking was very slow for some time, and gradually the shore end (on account of [illegible] tional weight) sank more rapidl[illegible] other, the water tending to collect [illegible]

This had been foreseen and three temporary transverse bulkheads built across the upper part of each tube, so as to trap the air and form an air chamber above the water at the lower end. Owing to leaks in the manhole stacks, however, the air escaped and the shore end sank quite rapidly until buoyed by the air cylinders; the other end was partially submerged but still high out of the water. This plunge caused some rapid scrambling on the part of the men who were looking after the air pipes, cables, etc. Air was then pumped into two buoyancy tanks at this end of the shell, which then rose until the structure again floated on an even keel, with its upper surface just awash. On the next day the shell was sunk to its bearing on the foundation grillage. It was found, however, to be about 3½ ins. out of line and 2 ins. below grade. By means of the tanks and cables it was finally adjusted to correct position, the correct elevation being obtained by means of shims placed under the bearing surfaces by the divers.

Two more sections are practically ready, and one or both of these may be sunk this season. Work cannot be carried on during the winter on account of the heavy ice running in the channel. The style of joints between the sections is of new and special design. The joint will first be roughly bolted up by divers by means of projecting flanges, and will then be sealed by filling an annular space 3 x 18 ins. with grout injected under air pressure through flexible pipes from scows on the surface. The details of the different parts of the construction work are liable to modification in line with the experience gained in sinking and placing the first two or three sections.

The approach on the Detroit side is 3,675 ft. long, with a grade of 2%. This is steeper than the grade of the Canadian approach, as the westbound trains are the lighter. The first 1,540 ft. is in open cut with retaining walls, and the first 500 ft. of the tunnel portion was also built in open cut, except part of the north tube, which was built by a shield on account of passing near the abutment of a city bridge. The center wall between the tubes was first built in a drift, and formed a guide for the roof shields of the arches. The concrete is placed in two layers, the outer and thicker portion being first placed. When this [illegible] set, it is faced on the inside with pitch and [illegible]terproofing, and the inner lining then [illegible] entire approach will probably [illegible]arly in 1909.

The approach on the Canadian side of the river is 6,500 ft. long, with a grade of 1½%.

The entire land tunnel will consist of two single-track arches 25 ft. c. to c. Each will have a semicircular roof and two side benches with vertical walls, leaving just room between these walls for the maximum car clearance. In these thick side walls are embedded the vitrified conduits for the electric wires. The floor is of concrete, flat, with drainage troughs, and having recesses on each side to receive wooden blocks upon which the rails will be laid.

Drainage will be provided for by sumps of ample capacity at the lowest point under the river, at the shafts, and at the portals. The water will be removed by motor-driven pumps. No system of ventilation has been provided, as the tunnel will be operated by electric traction, and no locomotives carrying fires or working steam will be allowed to pass through.

PRODUCER-GAS COMPOSITION AND ITS INFLUENCE ON THE PERFORMANCE OF SUCTION-PRODUCER PLANTS

By GODFREY M. S. TAIT

CONDENSED FROM "CASSIER'S MAGAZINE"

During the past four years suction producers have been gradually appearing upon the American market, and quite a large number of installations are now in operation, with more or less success, in this vicinity.

However, unfortunately the defects noticeable in the older type of pressure producers, such as variation in the quality of gas, inability to clean the fire without interfering with the manufacture of gas, necessity for having a spare unit, etc., are all more noticeable with the suction type than with the former type of pressure producers, with which a large gas holder was usually employed for the purpose of steadying up the output of the installation and allowing the gas to assume a more average condition before reaching the engine.

Almost without exception, some trouble has been experienced in every producer plant used for the operation of gas engines from irregularities in the operation of said engines, due to changes in the gas beyond the control of the operator, and it was with a view of ascertaining what these changes were, and to find, if possible, a remedy therefor, that the writer made a series of experiments on the subject, and with the following results:

In operating internal-combustion engines on a complex fuel, such as producer gas as usually manufactured, analysis of which I give herewith: it is noticeable that the heating value is composed of elements of widely different character, such as hydrogen and carbon monoxide.

		Per Cent.
1.	Carbonic acid (CO_2)	5.8
2.	Oxygen (O_2)	1.3
3.	Carbonic oxide (CO)	19.8
4.	Hydrogen (H_2)	15.1
5.	Marsh gas (CH_4)	1.3
6.	Nitrogen (N)	56.7
	Total	100.0
7.	B.T.U. per cubic foot of gas by calorimeter (high value)	136.

Following the matter up further, I made the discovery that the thermal or calorific value of the gas employed does not necessarily form a true index of the power value of a gas for engine work, and this was proven in the following manner:

An internal-combustion engine of the three-cylinder vertical type, rated at 100 HP. on producer gas containing 13.3% hydrogen and 23.8% carbon monoxide (plus a small percentage of marsh gas) and having a total calorific value, as determined by the calorimeter, of 138 B.T.U. per cu. ft., was found to develop a maximum under the very best conditions of 106 HP. By the very best of condi-

tions, I mean with the fuel in the producer free from clinkers and of sufficient gasifying depth to create a temperature to give the best results.

After obtaining this horse-power, I removed the apparatus for feeding steam beneath the bed of the producer, with a view to eliminating the hydrogen constituent in the gas. The gas under this condition showed 24.3% carbon monoxide, which constituted practically the sole combustible matter in the gas (with the exception of the small percentage of marsh gas above alluded to), this gas having a calorific value of 91 B.T.U. per cu. ft. With this gas and the same engine, I developed 114 HP. with ease, and was enabled to carry a load until the fire in the producer became overheated.

I then employed the exhaust from the engine under the fuel bed in the producer for the purpose of diluting the incoming air and reducing the temperature of the fuel bed. (In doing this, I was utilizing a patented process for flame and combustion temperature regulation now very largely known in several industrial fields).

Going a step further, I increased the compression of the engine to 200 lbs., on the assumption that, with no hydrogen in the gas, the tendency to pre-ignite would be absent, and the attendant advantages might as well be derived.

With this arrangement the producer operated with entire satisfaction twenty-four hours per day, with full or varying loads, while the engine, on the other hand, gave no trouble whatever, and there was an entire absence of pre-ignition, back-firing, etc., troubles which had been noticeable before. In addition to these advantages, the engine developed a maximum of 126 HP., and would carry 110 HP. with the greatest ease continuously, while, due to the high compression and accurate ignition produced when using a gas containing only one active constituent, the efficiency of the engine increased 15% above its former rating; that is to say, the total efficiency of the engine was 26% under these latter conditions.

When it is considered that the gas used in the second instance contained 47 B.T.U. less per cu. ft. than the gas used in the former test, and that in the face of this the efficiency of the engine and the horse-power capacity both increased to a marked extent, some idea of the importance of this deduction will appreciated.

I found that this increase in horse-power efficiency is due primarily to the fact that mixtures of gases whose components burn at different rates or velocities, such, for instance, as the usual mixture of carbon monoxide and hydrogen, usually known as producer gas, are not well suited for engine practice, and do not represent, by their total heating value, the amount of work obtainable from them in a gas engine cylinder, for ignition is either too early for the hydrogen, which is a gas of extremely combustible character, or else ignition occurs too late for the less combustible or slower burning carbon monoxide. Either state of affairs causes a loss of power, pre-ignition, back-firing or late ignitions.

At the present time the chief difficulty in operating internal-combustion engines with producer gas arises from the great variation in quality of the combustibles contained therein, which necessitates the closest attention on the part of the operator and the frequent adjustment of the air and gas valves on the engine, and it was while working out the cause of these variations and the remedy therefor that I made the above-mentioned discovery, that the thermal value of gas does not indicate its power value in an engine when it contains more than one combustible element, and that, owing to changes in the temperature of the fuel bed in the producer supplying the engine with gas, affected in turn by variations in the load on the engine, it is impossible to produce a gas containing fixed proportions of hydrogen and carbon monoxide; for, on the one hand, when the plant is running under a low load, the fuel bed, being cooler, will allow part of the steam to pass up through the fire without dissociation, merely superheating same, and this superheating of necessity carrying off heat units which are in turn lost in the scrubber water without having performed any useful work.

Owing to this varying quality of the gas, the time of ignition is rarely accurate, and this state of affairs gives rise on the one hand to pre-ignitions and on the other hand to back-firing.

It, therefore, would seem that in order to secure a constant, regular and steady run from the gas engine, only one combustible element should be present in the gas used. If the presence of other combustible matter, such, for example, as marsh gas, is unavoidable, the should be restricted to the least pos- t.

When producer gas is made, as has already been mentioned, by the passage through a fuel bed of a draft current containing air alone, provided that the fuel used consists largely of carbon, such as anthracite coal, charcoal or coke, the gas as produced contains only one combustible, namely, carbon monoxide, the balance of the gas being inert nitrogen.

Provided all the oxygen admitted is reduced to carbon monoxide, the finished gas should contain, theoretically, 34.7% of this monoxide. Each per centum of carbon dioxide present reduced to carbon monoxide being 2%, inasmuch as one molecule of carbon dioxide contains two atoms of oxygen, while carbon monoxide contains one atom, and consequently one-half of the oxygen of carbon dioxide. In other words, one volume of carbon dioxide on reduction by carbon will produce two volumes of carbon monoxide.

For the prevention of clinkering of the producer and for the purpose of so-called enriching of the gas, steam has hitherto been used, mixed with air, as the ideal blast for producers, it being claimed that the steam in the blast supplied a certain amount of oxygen for the oxygenation of carbon, without however, introducing nitrogen at the same time.

Hydrogen is produced in direct proportion to the amount of steam decomposed. It has been supposed, therefore, that hydrogen, in raising the heating value of the gas, increased its power value in an engine, and as for this reason, the greater the amount of steam employed, other conditions being equal, the higher the percentage of hydrogen; thus it was assumed that a greater value from the engine standpoint was obtained in the gas. However, as above mentioned, it will be seen that the assumption that the greater the proportion of hydrogen, the greater will be the power developed by each cubic foot of gas in a gas engine cylinder, is erroneous. It is true that a gas producer, under a pure air blast, will generally give a product having a lower calorific value per cubic foot than those operated with steam and air in conjunction; but it is not true that such a gas is a better agent for the development of power than a hydrogen containing gas. On the contrary, it is a far superior gas for power development in every practical respect, even though the gas so made should have one-third less thermal value than that of ordinary producer gas; the very fact that the former contains only one active combustible, with a fixed ignition point and adaptable to high compression, gives it the property, as already mentioned, of developing more actual power in an engine for reasons above mentioned.

It would seem, from the writer's experience, that this simple change in the lay-out of a producer plant has brought this character of installation up to a par with steam plants in point of reliability, while at the same time, so far from losing any of the acknowledged economies of producer-gas-operated gas engines, the efficiencies are considerably increased, and the writer feels that, as Mr. George H. Barrus said, after inspecting another installation of this character, "No steam plant could have operated with more complete regularity, and no more care was exercised in the handling than that given by firemen and engineers in the firing of a good steam plant."

It is interesting to note that engines employed under these conditions operate under compression upward of 200 pounds with entire freedom from pre-ignitions, proving conclusively that in whatever way hydrogen may or may not affect the pre-ignitions, they are not present in its absence.

CALCULATIONS FOR HOT-BLAST HEATING COILS

Formulas given in a recent issue of "The Heating and Ventilating Magazine" are as follows: Assuming approximately 35% of free area for the passage of air through the coils, the rise in temperature (degrees F.) of the air passing through heater,

$$R=(T-t)\div(\sqrt[8]{v})\ [(8/N)+0.24],$$

where T is the temperature of steam in coils, t the temperature of the air entering coils, v the velocity of the air passing through the coils in feet per second, and N the number of rows of 1-in. pipe in the depth of heater. The number of B.T.U. of heat given off per square foot of heater coil surface per hour per degree difference of temperature between the steam in the coils and the air entering same, is:

$$B.T.U.=0.22RV\div N(T-t),$$

where V is the velocity of the air through coils in feet per minute, R as obtained from first formula. In this expression it is assumed that the coils have 1.9 sq. ft. of heating surface per superficial square foot of coil area per row of pipe in depth.

NICKEL STEEL

By E. F. LAKE

CONDENSED FROM "MACHINERY"

Nickel steel is used to a large extent in the construction of high-grade machinery, and can be purchased in the open market today, in almost any percentages of nickel from nothing up to 35%, and with the carbon component varying between 0.10 and 1.00%. Thus it covers a wide field of usefulness in which greater strength, wearing qualities and other properties are demanded, than can be obtained in the ordinary carbon steels.

Nickel was added to carbon steel as the result of investigations which were started for the purpose of overcoming the "sudden rupture" that is inherent in all carbon steel product. This property or tendency of carbon steel to rupture is the subject of numerous investigations by the railroads of the country at the present time, owing to the many accidents that have occurred in the past few years being blamed to broken rails. Nickel added to steel largely overcomes this tendency, and we see it used successfully for parts of machinery that have to withstand high shock and torsional tests, such as the crank-shafts and connecting-rods of explosive engines, propeller shafts for marine and automobile use, and other parts of a similar nature which have to withstand similar strains and stresses.

Nickel gives to steel one peculiar property, in that it can be added in percentages up to 8, and the tensile strength and elastic limit will be raised by so doing, but in percentages from 8 to 15 these become nil, as a zone of brittleness is produced and no tests can be applied, but at 16% the strength and elastic limit are returned, and from there on these gradually decrease, while the extensibility increases.

The qualities of carbon steel are susceptible of change by heat treatment the same as alloy steels, but the higher the carbon content is, the more liable it is to burn and thereby reduce its strength, and it is extremely difficult to case-harden steels which contain more carbon than does mild steel without destroying their good qualities and streng
addition of nickel the tenden

largely overcome, and the extent to which it can be swayed by heat treatment is remarkable. This is best illustrated by Table I in which the steel was given different degrees of hardness. Its composition was as follows:

Nickel, 3%; carbon, 0.30%; maganese, 0.40%; phosphorus, 0.05%; sulphur, 0.04%.

TABLE I.—STRENGTH OF NICKEL STEEL AT DIFFERENT DEGREES OF HARDNESS.

Hardness.	Tensile strength, lbs. per sq. in.	Elastic limit, lbs. per sq. in.	Elongation in 2 ins., per cent.	Reduction of area, per cent.
Annealed	88,000	60,000	28	58
Medium hard..	130,000	130,000	20	6
Hard	220,000	190,000	12	37
Very hard......	225,000	225,500	8	19

A good quality, open-hearth, 0.30% carbon steel, as received from the mill in the untreated state, shows the same strength as the untreated nickel steel in Table I, but it cannot be raised to much more than one-half of the strength of the nickel steel in its hardest state, and even then it is much more liable to fracture under shock tests.

Thus annealing, hardening and tempering steel are resorted to for raising the tensile strength, elastic limit, and its ability to withstand shock and torsional tests, as well as to put a fine cutting edge on tool steels. For another example of this, a nickel steel containing silicon was heat treated as shown in Table II, and with the resultant strengths as shown.

In heat-treating steels for strength, and especially nickel steel, it should always be remembered that hardening by quenching produes internal strains which can only be removed or destroyed by tempering or drawing after it is quenched. Thus nickel steel cannot be used in its hardest state, and in which it has the highest tensile strength and elastic limit, for crank-shafts, connecting-rods or other parts of machinery that have to withstand similar strains and stresses, but the piece must be tempered, thereby reducing the strengths and increasing the elongation in order to reduce the brittleness as well as the internal strains caused by hardening. These internal strains may also be caused by forg-
hammering, or working, and the best re-

sults will be obtained if the steel is annealed after each important operation.

Three things work to the detriment of nickel steel and should always be taken into consideration when hardening it. First it nearly always warps in quenching; second it may be decarbonized in heating; and third, fissures and cracks might occur in quenching.

TABLE II.—EFFECT OF HEAT TREATMENT ON NICKEL STEEL OF THE FOLLOWING COMPOSITION.

Nickel, 2.51%; Silicon, 0.26%; Carbon, 0.33%; Manganese, 0.43%; Phosphorus, 0.023%; Sulphur, 0.032%.

Treatment.	Tensile strength, lbs. per. sq. in.	Elastic limit, lbs. per sq. in.	Elongation in 2 ins. per cent.
Quenched at 1,600° F.	225,000	208,000	4
" " " tempered at 600°	215,000	201,000	6
" " " " " 800°	190,000	150,000	9
" " " " "1,000°	170,000	145,000	12
" " " " "1,200°	155,000	125,000	14
" " " " "1,400	135,000	98,000	17
" " " " "1,600°	104,000	65,000	24

There are several rules which can be followed to minimize the tendency of steel to warp in quenching. If a piece is cut from stock that has been subjected to some mechanical treatment, it is very liable to be deformed on being heated, and it is undeniable that of the deformations attributed to the hardening process, a large part is due to the heating which precedes quenching, and results from the use of metal which has been mechanically worked. To overcome this, the steel should be thoroughly annealed before it is machined to size, so that the metal will be in a state of repose, and even then the tools used in machining may cause depressions in the metal that will cause warping when it is hardened.

In quenching, the piece should be immersed in the bath in the direction of its principal axis of symmetry, so that the liquid can cover the greatest possible surface, and it should never be thrown into the bath. Thus a shaft should be immersed vertically and a gear wheel perpendicular to its plane. The piece should also be agitated in the bath so as to destroy the coating of vapor which usually forms around the piece and prevents its cooling rapidly.

To reduce the tendency to decarbonize, it is necessary to provide against oxidation, therefore the atmosphere within the furnace must be kept as far as possible reducing, and the pieces must be prevented from coming in contact with the gases.

This can be done by placing the pieces in a protecting retort, or in using a metallic heating bath, such as one of lead.

Fissures or cracks which occur in hardening are caused by the different parts of the piece cooling unevenly, thus producing internal stresses of enormous proportions which sometimes produce brittleness and consequently fissures or cracks, as nickel ferrites have a lower degree of molecular cohesion than plain ferrites. These fissures may be prevented, by reducing the rate of cooling, in three different ways. One method is to cover water with oil from one inch to one inch and a quarter in depth. The second is to cool the pieces in a bath of a comparatively limited volume, so that the cooling is followed by a slight tempering, and the third is to withdraw the piece from the bath before it is completely cooled. This last requires considerable skill to obtain uniform results.

Nickel steel is one of the best steels on the market for gears, when carbonized, as different tests have shown that 2% of nickel added to the ordinary carbonizing steel will double, and in some cases more than double, the tensile strength after carbonizing, and these tests would prove that nickel steel should be used for carbonizing wherever the difference in price will warrant. It is from 2 to 2½ cts. per pound higher than the ordinary carbonizing steel, but the greater safety in manufacturing, and a consequent increase in the number of spoiled pieces, will largely overcome this difference in price.

If a 2% nickel steel is carbonized so the surface layer contains 1% of carbon, it will show pearlitic, when examined, but if a 7% nickel steel is used it will show a surface layer that is martensitic with a core pearlitic, or, in other words, the periphery has the same constitution as if it had been quenched and hardened while the core was in the annealed state.

The different materials used in carbonizing have different effects as to the penetration of the carbon and the time required for a certain penetration.

But a general rule for the rate of penetration at different degrees of temperature is as follows, the time being eight hours:

Temperature. In Degs. F.	Depth of Penetration.
1,300	0.000 inch.
1,475	0.0195 "
1,565	0.039 "
1,650	0.0625 "
1,700	0.08 "
1,750	0.110 "
1,800	0.125 "
1,850	0.165 "
1,900	0.195 "

Thus it will be seen that a rise in temperature of 150° doubles the rate of penetration, and in one case a rise of 90° has doubled it.

With the temperature held stationary at 1,850° the speed of penetration is as follows:

Time.	Depth of Penetration.
¼ hour	....
½ "	0.02 inch
1 "	0.31 "
2 "	0.40 "
4 "	0.50 "
6 "	0.80 "
8 "	1.20 "

The steel used for carbonizing should not contain over 0.2% of carbon, and the manganese component should be low, as this has a tendency to produce crystallization in annealing, and cause brittleness.

The cement used should be of a definite chemical composition which does not act abruptly, such as 60% powdered charcoal and 40% carbonate of barium, and two rules might be followed in treating; one being to carbonize at 1,600° F., cool to 1,400°, and quench; and the other is to carbonize at 1,850°, quench first at 1,650°, and the second time at 1,400°.

Nickel steel is not of as high a grade as nickel-chrome steel or the newer vanadium steel, but it stands a good second to these, is about two-thirds the price, and is so much easier machined and forged than nickel-chrome steel that it is used in preference to the higher grades.

In forging, great care must be taken to keep this steel at a high full forging heat and never hammer or roll it below this temperature, as cracks are then liable to occur. A great deal of talk is heard among the users of nickel steel about its cracking badly and being defective, and if defects occur in the bloom, they are pretty sure to show up somewhere in the finished product, but if the steel is properly rolled and forged these defects and cracks will not appear. Where carbon steel has been used for automobile axles and given way from fatigue, crystallization or other causes, heat-treated nickel steel has been substituted, and has given perfect satisfaction.

TABLE III.—INFLUENCE OF DIFFERENT PERCENTAGES OF NICKEL IN NICKEL STEEL.

Per cent. of nickel.	Tensile strength, lbs. per sq. in.	Elastic limit. lbs. per sq. in.	Elongation in 4.72 in. per cent.	Treatment.
1 to 1½	78,000	48,000	18	water-temp. at 1,650° F.
2½ to 3½	97,000	82,500	15	medium hard.
2½ to 3½	80,000	68,000	20	medium soft.
2½ to 3½	85,000	60,000	23 to 13	medium hard, structural
2½ to 3½	71,000	50,000	28 to 16	medium soft, structural.
4½ to 6	102,000	74,000	15	hard, for strenuous wk.
4½ to 6	121,000	107,000	12	hard, annealed at 1,600°.
4½ to 6	88,000	63,000	20	medium hard.
16 to 18	199,000	114,000	6	annealed at 1,650°.
22 to 26	110,000	45,000	40	annealed at 1,650°.
22 to 26	114,000	50,000	35	annealed at 1,650°.
30	80,000	28,000	44	annealed at 1,630°.

We frequently hear the boast of different manufacturers that they use 2% nickel steel for various parts of their machines, but this means nothing, as its properties depend as much upon the carbon content as on the nickel. To illustrate, one nickel steel that is largely used, and is the best for certain purposes, contains 2% of nickel and 0.12% of carbon. It has a high tensile strength and very little elongation, while another nickel steel equally good for other purposes contains 2% nickel and 0.9% carbon, and gives a high tensile strength with a great elongation.

Table III shows the different percentages of nickel in steel turned out by one manufacturer, and their strengths under different treatments.

These steels have percentages of carbon ranging from 0.10 to 1.00%, and those with the highest percentages of nickel are used mostly for valves, owing to their heat-resisting powers combined with a great strength. Sometimes from 1 to 3% of chromium is added to these valve metals to increase the elastic limit and mineral hardness.

THE NEW ALLOYS*

During the last three or four years a great number of new metallic alloys, with very varied properties, have appeared upon the market, amongst which we shall select the most important and give their composition.

Cupro-Magnesium (Cu = 90, Mg = 10) is utilized as a de-oxidizing agent, for unrefined copper, in the proportion of 1 per cent. The copper thus obtained has an electric conductivity less than that given by silicon for deoxidizing, but deoxidization is very easy by mere fusion, and very economical.

Phono-Electric Wires (Cu = 98.55, Sn = 1.40, Si = 0.05) are employed for telephones

*Specially compiled for "The Mining Journal" from "La Nature."

ıys. They withstand the effects of uch better than pure copper, though tric conductivity is only two-fifths ıre copper. In preparing this alloy totally sacrificed. Consequently it ıxist beyond traces in the alloy.

(Cu = 68.52, Zn = 12.84, Ni = = 0.76) is a kind of white metal; a for silver.

ese Resistance Metal (Cu = 85, Fe = 2) is a substitute for German silver, for resistance boxes for electric ents; specific electric resistance is 0ths to 4.5-100ths that of copper.

in (Cu = 82.12, Ni = 2.29, Fe = = 15.02) is also utilized for resistance d owes to the presence of nickel a fusion point and extremely low co- f temperature.

oof Metal (Cu = 82, Zn = 2, Sn = 8, particularly useful for paper works bisulphite process is employed for ıre of pulp. As a matter of fact, it roof against weak or diluted strong ept nitric, which quickly attacks it.

Metal (Cu = 49.94, Zn = 34.27, Ni = = 0.11, Fe = 0.28) is whiter than silver, which it can often replace, though less easy to work. It perfectly withstands the effect of salt water and air. Consequently it is chiefly utilized for marine engines.

Aluminum Silver (Cu = 57, Zn = 20, Ni = 20, Al = 3) is a white, very tenacious metal, which remains bright in air, and advantageously replaces steel whenever there is danger of rust.

Tempered Lead (Pb = 98.51, Sb = 0.11, Sn = 0.08, Na = 1.3) is manufactured by placing small fragments of sodium in the molten metal. This alloy is not so soft as lead, and can be rolled into thin sheets without tearing. When the percentage of sodium is rather great, tarnishing is prevented by coating the metal with paraffin. Thus formation of soda is prevented, owing to oxidation of the excess of sodium by atmospheric oxygen. For this reason it is valued for the manufacture of shaft bearings, because the soda formed, as the bearings wear away, saponifies the lubricant and produces a soap which acts even better than the oil.

Alkali-Proof Metal is iron with 5% to 10% nickel. All alloys containing zinc, tin, lead, aluminum, antimony, or silicon are readily attacked by caustic alkalies.

NERALS IN UNDERGROUND WATERS

FROM "MINING AND SCIENTIFIC PRESS"

ımical characteristics of underground pend mainly upon the composition of with which they have come in con- ing from point to point according to ıditions. The composition of the t only indicates the character of the determines the use to which partic- rs may be put. In fact a knowledge nificance of the mineral constituents ıter is essential to a proper appreci- its value and the limitations of its water analyses made in the labora- he United States Geological Survey the following elements, whose sig- and effects are briefly described in ving paragraphs:

Silica, a constituent of a great variety of substances, is present in large amounts in nearly all rocks except limestones and is contained in measurable quantities in nearly all underground waters. The amount ordinarily held in waters is too small to be injurious to health or objectionable in the majority of industrial processes; but the mineral forms a part of boiler scale and on this account it is undesirable in waters used for steam-making.

Iron is a constituent of most rocks and is dissolved to a slight extent by percolating water. Four or five parts per million of this substance render water unpalatable, and two or three parts per million are distinctly recognizable by taste. The iron is generally pre-

cipitated on exposure of the water to air, forming a brownish coating on the sides and bottom of the containing vessels and a scum on the surface of the water, but leaving the water itself almost free from iron at the completion of the process. Water containing much iron is very objectionable in laundries, bleacheries, textile factories, and paper mills, because the element distinctly discolors white fabrics and interferes with the coloring of tinted varieties. In the manufacture of fermented beverages iron produces a dark-colored brew that is unattractive in appearance. Iron also causes trouble in water pipes by the development of micro-organisms that secrete this substance and form a reddish slimy deposit that clogs small pipes and frequently is discharged through faucets. Iron forms part of the scale in boilers, though the amount that may be present is small in comparison with that of other incrustants.

Aluminum is a constituent of practically all rocks and forms a large proportion of shales. It unites with lime to form boiler incrustations. It is relatively inert and is harmless to health in the small amounts that are ordinarily present.

Calcium is present in a great variety of rocks. It is one of the chief ingredients of limestones and consequently it predominates in waters draining such deposits. It causes great trouble in boilers, where it forms a deposit that seriously affects their efficiency. If carbonates predominate in the water, the deposit is a soft bulky sludge that is not trublesome if it is frequently removed by "blowing off." If, however, sulphates are present, a hard scale is formed that clings tenaciously to the surfaces on which it is deposited.

Magnesium is commonly associated with calcium in rocks, but generally occurs in smaller amounts. Although its compounds are more soluble than those of calcium it is usually present in ground waters in smaller quantities. It is a more objectionable constituent of boiler waters than calcium. It forms denser and harder scales, especially when precipitated with calcium carbonates, with which it unites in a hydrated incrustation that is as hard as porcelain. Its compounds are also readily decomposed, so that the acid radical attacks the boiler-plates.

Calcium and magnesium are always present in underground waters and are the chief bases in the drainage from limestone regions. They are the so-called "hardening" constituents, and for general industrial uses, especially in laundries, textile mills and soap factories, where they form an insoluble soap and thereby greatly increase the consumption of the detergent. In dye works the alkaline earth compounds interfere with the coloring matters.

Sodium and potassium occur in nearly all rocks and are present in greater or less amounts in ground-waters. The compounds of these two elements form no part of the scale in boilers because they are readily soluble in waters, hot or cold. On the other hand, on account of the acid radicals which accompany them, they are the cause of foaming and corrosion. Strong solutions of the carbonates cause foaming, but are not specially corrosive. The sulphates often associated with the alkalies are both foaming and corrosive.

Chlorine has an important corrosive action whatever base may be associated with it. Water contaning over 100 parts per million of chlorine is poor for boiler purposes. In water for drinking chlorine is harmless.

The total solids in a water depend largely on the character of the rock it traverses and the intimacy of contact of the percolating waters with it. They are lowest when the waters have just entered the rocks and highest when they have been imprisoned for a long time. They are smallest in porous quartz sandstones and highest in fine-grained shaly rocks, through which waters pass with difficulty. In general it may be said that the smaller the amount of dissolved mineral matter in the water the better it is for steaming and for general industrial purposes.

DEPRECIATION*

By ALEXANDER C. HUMPHREYS, D. Sc.

...st may become a very serious item ...ich we rather loosely denominate as ...ion are: Obsolescence, Inadequacy, Decay.

...st may become a very serious item, ...een found in the electric lighting and its neglect has led and may lead passed dividends.

...uacy is also important and hard to estimate. Here comes in the ques... ...riginal layout. The plant may have ...gned to meet present needs and hon... ...structed but manifestly inadequate ...arge increase in business. Some in... we are sure to encounter sooner or ...ess the plant was originally laid out ...e not warranted at the outset of the ... We are continually having to question of inadequacy in our dis... systems. While some mains may ...nore than ample in capacity, others ...l to be inadequate. In other words, ...ess has developed as a whole, and ...districts has developed along lines as ...ot expect, leaving us with a surplus in directions we had estimated for ...ally. Finally we have physical de... ...fortunately, laymen and some ac... ... are too apt to think that this last ...y item to be really considered. Here the theory that if you have assumed ...uture a certain average life of plant, ...arry that estimate back over the past ...e it apply to present values of plant ...y determining the expired average ...o establishing a ratio of depreciation to the plant as it at present exists. ...ould be more fallacious. If the de... ... estimate had been the same as that ...ted, it would still remain to analyze ...nts and compare item by item with as found by experience and by ex... ... of the plant and accounts. For we might have estimated an average ... years for the mains, taking into ac... ...e question especially of inadequacy; ... we come later to apply that esti... the present condition of plant, we might find that the business had not developed as had been assumed, that the growth had been along lines not before contemplated, and that these districts had been covered by new mains and that the mains as originally laid were still adequate, and being cast iron pipe, well laid, they were not obsolete, and showed practically no physical decay, the condition as to joint leakage, etc., having been maintained by efficient current repairs.

Furthermore, any unamended original estimate will be upset by reinvestments of depreciation fund in new plant for extensions; while if depreciation is cared for by sinking fund, the working value of plant is not necessarily the original value minus the estimated depreciation, as that would mean that depreciation is evenly spread and evidenced over all the years of plant's life. If such were the case, there would be no need of any estimates in connection with depreciation.

On the other hand, a plant might be found which was in perfect physical condition, but which was greatly reduced in value by reason of obsolescence or inadequacy.

Here is where the appraisal of a plant by a man really expert in the business, expert as a constructor and an operator, comes in to clear up questions to date. Such an appraisal can give the actual present value with regard to obsolescence, inadequacy and physical decay. As to the two first elements, the expert can, through the exercise of his trained judgment, in connection with a study of the plant and the business, arrive at the truth. As to the last element, he may not be able to see all working and hidden parts, but by a thorough examination of the plant, supplemented by a close scrutiny of the methods followed in operation, including repairs and current renewals, he can very closely appraise the value as to this element.

Having disposed of the elements of obsolescence and inadequacy, a man really expert as a constructor and operator may well discover that certain of the parts of plant, although erected some years before, are as good as new, and in some special cases he may find parts which he would prefer to the equivalent apparatus then purchasable. And still there

*...from a paper read before the American Gas ... Washington, D. C., Oct 18, 1907.

is absolutely nothing in this statement in opposition to the proposition that provision should be made for equalizing, as far as possible, the cost of depreciation over all the years involved. Anything like a full comprehension of this important and puzzling subject must at once convince that for its solution is required not only the best efforts of the thoroughly competent constructing and operating engineer and manager, but also the best efforts of the thoroughly competent accountant.

It is evident to any practical man who has really studied the subject of depreciation that no general rules can be followed in the preparation of a depreciation life table, for necessarily this is in each case a matter of estimate based upon an expert consideration of present conditions as to character and condition of plant and future conditions as to care of plant, methods of accounting, changes in the art and growth of the business; and as to the future, in addition to probable physical deterioration, as before said, we must particularly consider the probable effects of obsolescence and inadequacy. Furthermore, the table as originally made up should be modified and corrected as conditions demand from year to year.

These being the facts, it is all the more important that the life table as mathematically developed should correctly represent the assumptions included in the general life estimates, and that we should not add to our difficulties by introducing errors of theory.

On page 117 of "Lecture Notes on Some of the Business Features of Engineering Practice"* appears the following:

"It is well here to draw attention to a mistake which is sometimes made in estimating the average life of a plant. Take the case we have already considered and the calculation might be as follows:

Part of Plant.	Years.		—Value of Parts in Dollars.—	
A	10	×	25,000	250,000
B	15	×	50,000	750,000
C	25	×	100,000	2,500,000
D	35	×	150,000	5,250,000
E	50	×	175,000	8,750,000
			500,000	17,500,000

17,500,000 ÷ 500,000 = 35 years average life."

(If the average life of the plant were as long as 35 years we find by referring to the annuity table that it would require only 1.358 per cent. of the total value of the plant, that is, $6,790, set aside each year at 4 per cent. compound interest to rebuild the plant as a whole at the end of the 35 years of life.)

I then show, step by step, that $6,790, the amount that would be sufficient under a 4 per cent. compound interest sinking fund plan to redeem $500,000 in 35 years, if left undisturbed, would not be sufficient to provide for the renewals of the several parts of plant in accordance with the assumed life table.

Although this part of the subject was so covered at considerable length, I now find that it is advisable to go further, and especially to answer two questions which have been asked.

Some say: "Why should anyone expect such a calculation to give the average life?"

Others say: "While it is apparent that this process does not give the correct result, why does it not do so?"

As to the first question, I can only suggest that those who have fallen into the error have done so by confusing this case with other cases not so complex.

For instance, if we had 25,000 castings weighing 10 pounds each, 50,000 castings weighing 15 pounds each, 100,000 castings weighing 25 pounds each, etc., we could find the average weight of the 500,000 pieces by the process shown above. Or, if we had 25,000 yards of cloth costing 10 cents a yard, 50,000 yards costing 15 cents a yard, 100,000 yards costing 25 cents a yard, etc., we could find the average cost per yard by the same process.

This answer replies to the first question, but makes the difficulty of those asking the second question all the greater; they now say, "If this calculation is correct in the case of averaging weights, costs, etc., why is it not correct for averaging the life of a plant?"

The reply is that the process would be correct if it covered all the elements of the proposition and was correctly applied.

To better follow the several points involved, let us consider this process of averaging in the case of a plan for meeting depreciation without the aid of interest accumulation. In this case, if certain parts of the plant valued at $25,000 are to be renewed in 10 years, then each year we must lay aside to meet the depreciation of these parts $^1/_{10}$ of $25,000. And so we would require $^1/_{15}$ of $50,000, $^1/_{25}$ of $100,000, etc. The total amount required

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*Published notes of President Humphreys used by his classes at Stevens Institute of Technology, Hoboken, N. J.

each year would then be $17,619, derived as follows:

1/10 of	25,000	=	2,500
1/15 of	50,000	=	3,333 1/3
1/25 of	100,000	=	4,000
1/35 of	150,000	=	4,285 5/7
1/50 of	175,000	=	3,500
	500,000		17,619

But if the correct average life were 35 years, the total amount required each year would then be (omitting interest, remember) 500,000 ÷ 35 = $14,285.71.

Now let us see why 35 years, and $14,285.71, derived therefrom, are not correct.

If we are to find the average life of the plant, we must state our proposition so as to include all the dollars involved in the full 50 years period. For instance, during the 50 years we have to take care of Parts "A," $25,000, five times, for these parts have to be renewed every 10 years. So for all parts we shall have to consider the number of times they will have to be renewed during the 50 years period.

Bearing this point in mind, the proposition stated on page 117 of the Notes will then take this form:

TABLE "A."

1	2	3	4	5	6
Part of plant	Yrs.	Value of parts in dols.	Times renewed in 50 yrs. period.	Total requirement in 50 years period.	Dollar-Years being amounts in col. 2 multiplied by amts, in column 5.
A	10	25,000	5	125,000	1,250,000
B	15	50,000	3 1/3	166,666 2/3	2,500,000
C	25	100,000	2	200,000	5,000,000
D	35	150,000	1 3/7	214,285 5/7	7,500,000
E	50	175,000	1	175,000	8,750,000
		500,000		880,952	25,000,000

In explanation of the above table it is seen that, having calculated the total number of dollars required during the 50 years for each class of plant, we then in each case multiply by the number of years during which each dollar (or the plant which the dollar pays for) does duty. Thus we obtain the result shown in column No. 6, namely, the "dollar-years."

Dividing now the total dollar-years by the total dollars to be provided during the 50 years, we have 25,000,000 ÷ 880,952 = 28.3783 years, as the true average life of the plant represented originally by $500,000.

If our result is correct, the amount required each year to cover depreciation (omitting interest) should be the total number of dollars to be supplied during the 50 years divided by 50 — that is 880,952.38 ÷ 50 = $17,619; and it should also be the original value of plant divided by 28.3783, the average life of plant; that is, 500,000 ÷ 28.3783 = $17,619. And, without considering the question of average life, we have already found that to replace each year 1/10 of $25,000, 1/15 of $50,000, 1/25 of $100,000, 1/35 of $150,000, and 1/50 of $175,000 requires $17,619.

So we find that if the process indicated on page 117 is correctly stated, performed and applied, we get a true average life of 28.3783 years, requiring an annual payment from profits of $17,619, to provide for depreciation without interest accumulations.

To guard against possible misconception as to the so-called average life of plant in connection with the sinking fund method of providing for depreciation, we may well consider in a little more detail the difference in this respect between the compound interest sinking fund process and the direct method in which is set aside each year the actual amount of estimated depreciation.

In the case we have been considering—referring to page 116 of the "Notes" and Table "B" to follow—we find that the amount required to care for depreciation of the $500,000 by the 4 per cent. compound interest sinking fund scheme is $10,163.50, which is 2.03 per cent. of the $500,000; and this 2.03 is almost exactly the per cent. required to redeem the total original cost of the plant in 27¾ years, provided the sinking fund is not disturbed: and furthermore, this per cent. is sufficient to pay for the recurring renewals of the several parts, "A," "B," "C," "D" and "E," in accordance with the life table assumed.

But we have seen by the calculations made in these supplementary notes that, by the direct method of setting aside each year the actual amount of depreciation, the true average life is 28.3783 years. In this particular case these two figures, 27¾ and 28.3783, are so nearly the same that one might be led to suppose that they should be in actual agreement, and that the difference is due to lack of exactness in the compound interest calculations. A little thought will show that an agreement should not here be looked for.

In the direct method we are arriving at a true average life—that is, the "average life" is the number of years elapsed when the plant will have depreciated an amount equal to the first cost, and hence necessarily the number of years when the accumulated payments to cover depreciation will have amounted to the first cost of plant.

Whereas, in the compound interest sinking fund scheme, the average life (if we permit ourselves to use this term) simply means the number of years required for a certain annuity to accumulate to an amount equal to the first cost of plant, provided no withdrawals are made; the amount of this annuity with its interest accumulations being such, however, that when, from time to time, it becomes necessary to make withdrawals to cover depreciation in accordance with the provisions of the scheme, there will always be found in the fund a sum sufficient to meet these recurring demands.

By the direct scheme (no interest) the accumulation of annual payments in the fund must necessarily be equal at the end of any year to the accrued depreciation. By the compound interest scheme this necessarily would never be the case unless a time was reached when all the parts of plant expired at the same time.

For instance, in the life table now under consideration, there is always an overlapping of the life periods of the several parts of the plant, and so there will never be in the fund sufficient to meet the total accrued depreciation, though there will always be enough to meet the requirements as to each part of the plant as it has to be renewed. This means that when this overlapping of life period occurs, as it probably always would in practice, the compound interest sinking fund scheme, strictly speaking, is only applicable to the case of a plant operating in perpetuity.

To illustrate: On pages 122 and 123 of the "Notes" it is shown that by the sinking fund scheme we should have in the sinking fund at the end of 50 years, after making all payments required for the renewals of parts "A," "B," "C," "D" and "E," $54,195. The calculations are then made to show what should be the accrued sinking fund liability on account of the depreciation of parts "B" and "D," the only parts the lives of which overlap the 50 years included in the table. It is shown that the 5 years' sinking fund liability on parts "B" and 15 years on parts "D" will amount to $54,312 [illegible] being practically in agreement with the balance shown in the fund.

But this is not the actual accrued liability for depreciation [illegible] which would amount to: [illegible]

[illegible] accrued [illegible]

[illegible]

[illegible] 15 years accrued. [illegible]

[illegible] 64,[illegible].71

$[illegible].37

It is thus seen that the compound interest sinking fund scheme, and the simpler scheme, which eliminates interest accumulations, are essentially different in operation. In connection with the sinking fund scheme the term "average life" is misleading, whereas, by the direct scheme the true average life, if desired, can be determined by the method shown in this supplementary note.

To further illustrate that the true average life (as far as it can be true, based upon estimate) will not be the same as the time during which a sinking fund scheme, if undisturbed, will accumulate the total value of plant, we may add a 2 per cent. and a 6 per cent. sinking fund scheme to the life table already used. To make the comparison more apparent, I will include in the one table these two schemes, the original 4 per cent. scheme and the direct scheme which entirely eliminates interest:

TABLE "B."

Parts of plant.	Est'd. life in years.	Value of plant in $	Amount to be set aside each year to cover depreciation. 6 per cent. sinking fund.	4 per cent. sinking fund.	2 per cent. sinking fund.	0 per cent. no interest.
A	10	$25,000	1,896.75	2,082.25	2,283.25	2,500.00
B	15	50,000	2,148.00	2,497.00	2,891.50	3,333.33
C	25	100,000	1,823.00	2,401.00	3,122.00	4,000.00
D	35	150,000	1,345.50	2,037.00	3,000.00	4,285.71
E	50	175,000	602.00	1,146.25	2,068.50	3,500.00
Total value of plant and total annual payments		500,000..	7,815.25	10,163.50	13,365.25	17,619.04
Annual payments in per cent. of plant value			1.563	2.03	2.673	3.524
Years required to redeem total value of plant..			27.05	27.73	28.2	28.378

It is thus seen that as the interest rate of the sinking fund increases not only will the annual depreciation payment be reduced in amount but, if we stipulate that in the meantime no withdrawals shall be made as in fact called for by the life table, then the time required to accumulate the total value of plant will also be reduced.

This seeming contradiction is the result of this stipulation, necessarily introduced for this time comparison. For we must remember that the amounts actually withdrawn to meet partial depreciations ("A," "B," "C," "D" and "E") in accord with the life table, will be the same, no matter what the sinking fund rate of interest; and as we assume that these amounts are to be left in the fund and allowed to accumulate, the higher the rate of sinking fund interest the greater will be the tendency of these accumulations to reduce the time in which the total value of plant will be produced.

It is true that there is another factor involved in this comparison of so-called average lives, though no reference to it is apparently called for by the comparative figures above given. So where the factor just explained tends to shorten the so-called average life, this second factor here tends in a minor degree to lengthen it.

That is, the higher the sinking fund rate of interest, the smaller will be the sinking fund liability for each part between the several withdrawal dates; therefore, the slower the accumulation and a consequent tendency between withdrawal dates to lengthen the so-called average life. While this tendency ceases for each part at its withdrawal date, the tendency is always in force with some of the parts, and therefore always affects the scheme as a whole.

I may avail myself of this opportunity to answer another question which seems to have puzzled a number of the class: "Why complicate the problem of depreciation with questions of compound interest; why not each year take out of profits for plant which will have to be renewed in 10 years, 1/10 of its cost, for plant which will have to be renewed in 15 years, 1/15 of its cost, etc., and then let the interest on the depreciation fund be absorbed year by year into the profits?"

This is exactly the case I have covered in the sixth paragraph, page 129, beginning: "The simpler and more usual arrangement." I also refer to this plant on pages 138 and 139. The objection is the larger amount required in the first instance to cover the annual depreciation charges.

We have seen that by the more direct method it would require $17,619 a year taken out of profits, whereas by the 4 per cent. sinking fund scheme it would require only $10,-163.50; that is, 3.524 per cent. of the cost of plant instead of 2.03 per cent. of cost.

This difference might prohibit the adoption of the simpler plan, especially in the early days of a new venture.

I am chiefly concerned to convince you that depreciation should be provided for out of profits, and I have therefore shown the necessity of accurately estimating the depreciation and the manner in which the means may be provided for meeting the item of loss with the least burden to the business.

Let me also emphasize the point that if a certain portion of the profits are, year by year, invested in plant extensions to cover depreciation, we must be careful to keep our accounts so that there will be no excuse offered for issuing additional bonds or capital stock against these additions to plant, for by this method we have simply made good the depreciation of certain parts of plant by adding other parts.

As far as gas companies' practice is concerned, too much stress has been laid upon the sinking fund method of financing depreciation. I confess that I may have erred in this direction. In my address as President of the American Gas Light Association (1899), I laid particular stress upon the necessity for some systematic provision being made to meet depreciation, and I then discussed the sinking fund method. I was partly led to this by the desire to interest those who might look upon the full burden as too heavy to be at once assumed. But in this case, as in every other in which I have written or spoken on this subject, I have never neglected to point out that, if the depreciation fund were reinvested in plant extensions, the interest on these investments by one means or another must be added to the depreciation fund, so showing that the sinking fund payment was not the full cost of depreciation. In my earlier efforts to arouse interest in this subject, I was more interested in the practical and engineering features of the problem and not so much in the accounting feature. I was then satisfied to state what I considered the principles which govern rather than to lay stress upon the details of accounting.

Attempts have been made to cover the subject of depreciation by tables showing the length of life for each class of plant. It is true that in some cases in connection with these tables warnings have been given to the effect that such tables are only of general value and should not be blindly accepted without regard to local conditions. Such tables are no doubt of some value when used by those competent to form independent judgments.

Arguments as to the cost of depreciation have also been based upon comparisons of costs per thousand of repairs and current renewals. As I have repeatedly stated, the cost of depreciation must be considered in connection with the declared cost of these items, but here any fair comparison cannot be made unless we have analyzed the character of the work performed and the methods of accounting followed in each case.

Before closing let me say a word as to the necessity of creating a reserve, over and above

depreciation reserve, to cover the fluctuations in prices of materials and labor, extra hazards of the business, contingencies which cannot be estimated on.

Let me bring this much-extended paper to a close by summarizing some of the more important features to be considered in connection with this all-important subject of depreciation.

First, let it never be forgotten that any life table employed must of necessity be based upon estimate.

That being the case, the life table should be corrected and amended from year to year as required by changes in limiting conditions.

The probable amount of physical decay will depend upon original design and construction and methods pursued as to maintenance.

The estimate on each life period must be based upon consideration of probabilities as to obsolescence, inadequacy and physical decay. In the life table each class of asset must be treated by itself, and each class of asset must be provided for as to renewal, and each repeated renewal within the period set by the longest life included in the table.

The cost of depreciation must not be confused with figures obtained by considering the financial methods to be employed in caring for depreciation. In any case, the annual loss will be the total cost divided by the net total effective years of service.

If the loss is covered by a sinking fund, then the interest accumulations must be recognized as part of the cost.

The cost of repairs and current renewals must be taken into account in considering the cost of depreciation, and, all other things being equal, the more complete the former the less costly the latter.

THE EFFECT OF VANADIUM IN STEEL

By E. T. CLARAGE

FROM "THE IRON TRADE REVIEW"

Vanadium is not a new discovery. Its existence was known as far back as a century ago under the name of "erythronium." It was not until thirty years later that it was again found and given its present name.

About 40 years ago Sir Henry Roscoe is credited with having obtained the pure metal and learning something of its properties, particularly its ability to combine with oxygen.

Until recently it has been classed as one of the rare metals, although it has been used experimentally in steel since about 1902 and it was also used in small quantities by the English wire drawers some 18 years ago. It was found in such small percentages in combination with other metals that the cost of reducing it made the price prohibitive. Even up to a year ago the price has been ten dollars a pound or over. A large deposit has recently been discovered in South America as a sulphide, and although the present cost is a little more than half the price of silver, it may be possible that as the demand increases the cost may be still further reduced.

For many years it has been an axiom that phosphorus and sulphur were the two deadly enemies of steel. The wonderful science of chemistry is only a little over a hundred years old and its application to the art of steel making dates back not much more than half that period.

The most advanced metallurgists have just begun to appreciate that there are other elements which are much more harmful, and which have rarely been computed. The two exceedingly elusive gases, oxygen and nitrogen, are usually present in small quantities in all forms of steel and the presence of either one is exceedingly harmful.

In the Bessemer process the carbon in the iron is burned out by forcing an immense quantity of air through the molten mass, the oxygen combining with the carbon, and the other constituent of air, or nitrogen, nearly all passing off without producing any kind of an action.

Unquestionably a certain amount of the nitrogen gas remains in the steel. In fact, an analysis will show the largest amount of this gas in Bessemer steel, a smaller amount in open hearth and a very much smaller amount in crucible steel. This is probably the reason

a crucible steel is much superior to the open hearth, even though the carbon, ganese, phosphorus, sulphur and silicon be the same in each.

e value of the Bessemer process to the l is almost beyond calculation, yet in the of recent discoveries and developments ll eventually be considered as only a step e process of evolution, and unless modi- or greatly improved it will certainly have re way to the open hearth method.

nadium even in very small doses has the rty of combining with both oxygen and gen at high temperatures. In fact it acts purge or cleanser in driving them out of netal. So powerful is its influence on ni- n that one-half of one per cent. is suffi- to eliminate nitrogen entirely. In intro- g this amount, about one-half of the dium will be found in the steel and the nce of even one-tenth of one per cent. e finished steel is a guarantee that the gen has been separated from the steel and n out.

e effect on oxygen is the same, but this t nearly so important as we have other less expensive material which will take of the oxygen under ordinary circum- es.

anganese is a de-oxidizer and metallic inum is still more effective. Theoreti- 229 parts by weight of manganese will ine with 100 parts of oxygen (Mn_3, O_4) 113 parts of aluminum will combine with ame amount ($Al_2 O_3$). The peculiar value luminum is in the fact that when intro- d into the melted steel in just the right ortions it passes into the slag or flux as of aluminum, combining with silicon to n it to its original state of finely divided and leaves no trace of itself or oxygen in steel.

e analysis of nitrogen in steel is theoreti- very simple, yet it is a very difficult an- s to make and quite beyond the ordinary ist.

r liberating the nitrogen and combining hydrogen gas, ammonia is formed, ammo- being 14 parts by weight of nitrogen and rts hydrogen (NH_3). The amount of ni- en in the resulting ammonia can be easily uted. But these two gases will only com- under certain conditions which are very ult to attain.

addition to its chemical action on nitro- and oxygen, vanadium also produces an- r result which has been called a mechanical action, although it is more properly another chemical combination.

Under the microscope a piece of hardened steel which has been surface polished and etched will show the hardening carbon in the form which has been called martensite and which in a piece of pure carbon steel will be found in irregular splotches. Prof. Arnold is of the opinion that vanadium combines with carbon to form a double carbide of iron and vanadium which may account for a part of its physical effect.

The microscope reveals beyond question that the presence of this alloy causes a different arrangement of hardening carbon, it being more uniformly knit together throughout the mass.

The physical characteristics of vanadium steel are higher tensile strength, (breaking point) higher elastic limit (stretching point) and resistance to fracture from successive shocks.

F. W. Harbord in his last edition of metallurgy of steel says a nearly pure iron and carbon steel containing about 1.10% carbon has an elastic limit of about 60,000 lbs. and a tensile strength of about 120,000 lbs. per sq. in. He states that as small an amount as 0.14% vanadium has raised the elastic limit to 86,000 lbs. and the tensile strength to 134,000 lbs. He reports the effect of 0.3% in the same steel as giving 152,000 and 0.6% 190,000 lbs. tensile strength, the last having an elastic limit of nearly 130,000 lbs. per sq. in.

Nearly all recent experiments have been made with open hearth steel in which phosphorus and sulphur ran as high as 0.03 or 0.035, which is way above the limit even in ordinary low priced tool steel.

It must not be supposed for an instant that vanadium is a miraculous substance which will neutralize the effect of phosphorus and sulphur, and the steel maker or consumer who is led astray on any such idea still has his troubles ahead of him. It is a fundamental fact that results obtained with any combination having iron as its base will be in direct proportion to the amount of phosphorus and sulphur present.

We now come to the most interesting feature of vanadium from the standpoint of the tool steel maker.

A hundred and fifty years ago when the steel maker knew nothing about chemistry, he found simply by experiment that certain Swedish irons make the best steel. This be-

came tradition, and to this day we are still guided by it. These Swedish ores are found in a remarkable state of purity and are smelted and refined entirely by the use of charcoal as a fuel in order to prevent the iron taking up any sulphur.

It is possible, starting with the purest American irons, to eliminate phosphorus and sulphur to a great extent, in fact American iron can be produced as low in these impurities as the best imported iron. Nevertheless there is a distinct difference in the quality of tool steel made from them. The old steel maker will tell you that the Swedish irons have the "body" and it is a fact that only a few pounds used with the American iron will have a noticeable "toning up" influence.

Prof. John W. Langley tells me that he made an exhaustive study of this subject some 15 years ago and that he found that the best Swedish irons were practically free from nitrogen which was always present in the American irons. As this is the only difference he could find between the two, he was obliged to think that nitrogen was the element which was responsible for the different results.

The German technical paper, "Stahl und Eisen," recently gave the results of some determinations on the influence of nitrogen in iron made by H. Braun, who discovered alterations in the physical properties of the metal. An iron wire of the composition of 0.08% carbon and 0.027% nitrogen was nitrated with dry ammonia gas. After nitrating, the percentage of nitrogen was found to be 0.267%.

The original wire stood 15 or 16 deflections. The nitrated wire was unable to stand more than two or three.

Curiously enough we are only beginning at this late date to discover the reason for the Swedish iron being so much more free from this element. Prof. Howe in his "Metallurgy of Steel" speaks of vanadium and says that Sefstrom discovered it in the bar iron and refinery slags from the Taberg (Swedish) ores He states further that Riley has found 0.686% of it in the cast iron.

Mr. J Kent Smith, who is at present connected with the production of vanadium in America, is quoted as saying that his first experience with vanadium was in a piece of Swedish iron which had done remarkably good work. He further states that this iron contained a considerable amount of vanadium and adds that most Swedish irons contain some.

In the light of present developments it is evident that the finding of vanadium in the slag was evidence that it had performed its remarkable function in carrying off nitrogen and oxygen, and its presence in the refined irons was a guarantee that there was no more of these elements present.

There is certainly a great field for this alloy in open hearth and Bessemer steel where its cleansing effect is most needed, but if tool steel is made fro mthese pure high grade Swedish irons the purging action has already taken place and there is little or nothing to be gained along the same lines by adding more.

It is a well known fact that a low grade tool steel deteriorates much more rapidly under successive hardenings than a high grade product. The process of hardening itself is a tremendous shock to the material as a result of the sudden contraction. One of the most important results from the use of vanadium is that the resistance to dynamic strains or shocks is greatly increased. Therefore a tool steel made from these Swedish irons which contain even traces of vanadium will outlast the ordinary low priced tool steel many times.

I do not mean to say that vanadium will not be used in tool steel. In fact it has other properties which may make it eventually a substitute for tungsten in the manufacture of high-speed steel, when the cost is such that it can be used in larger proportions.

Man has accomplished wonders in combining the elements synthetically in imitation of nature, but there remains much to be done.

The diamond is simply a form of pure carbon, but its production in the laboratory has not yet been accomplished in a commercial way.

We are obliged to admit that there are processes in nature's laboratory that man can not imitate or even faintly comprehend.

Nature effected a combination of vanadium and iron in the Swedish ores millions of years ago, and at the same time was kind enough to furnish them almost free from phosphorus and sulphur.

The tool steel maker who makes use of the best product of nature's laboratory can be reasonably sure of the quality of his product.

THE DESIGN OF WATER-COOLING TOWERS

FROM "THE ELECTRICAL ENGINEER" (LONDON)

Previous to calculating the size and capacity of a cooling tower it will be advisable to determine the type of tower to be used. For this purpose a brief description of standard towers follows. Of course, to fit any exceptional case a combination of different types could be effected, but this is not advisable, in view of the extra cost of altering makers' patterns, etc. Water-cooling towers can be divided into four classes or types. Each type or combination of types has its own sphere of usefulness, according to duty, locality, etc. A certain kind of tower may be chosen, set to work, and duly condemned as useless, solely because it was erected in a wrong position, or that it cannot be extended, etc., when a tower of similar design with slight modifications would have been an efficient and useful addition to the plant. All designs of cooling towers are based on the power of air to evaporate water and absorb it as vapor. The amount of moisture air is able to absorb varies according to the dryness and temperature of the atmosphere. On a cold day the efficiency of a cooler is increased, but when misty the efficiency is decreased. As, generally, it is cold when misty, the weather factor can be neglected.

Construction.—All towers of different makes are designed on very similar lines. In all the water is delivered into a trough from 20 ft. to 30 ft. above the ground level; from this trough it either flows or trickles down through the cooling or water stack. This cooling stack extends from the distributing trough down to ground level, and is fitted with rough unplaned boards inclined to the horizontal, so that the water trickles from one to the other, and is broken up for greatest contact with the air. One make of tower is fitted with curved splash bars, arranged in such a manner that the water does not pour or trickle, but falls on the curved bar and rebounds. This splashing and rebounding divides the drops into many minute particles, thus more intimately mixing the air and water. In some designs the stack consists of earthenware pipes, and in some metal grills and mats.

Tower or Chimney Cooler, Natural Draft.—This pattern is the most commonly used, especially where space is not limited. There are no fans, all the power required is for pumping the water into the distributing troughs. Above the water stack is a wooden chimney. This chimney varies from 20 ft. to 50 ft. in height, making a total tower height of from 40 ft. to 80 ft. Around the lower part of tower or cooling stack are louvre boards, which serve a double purpose of keeping the water from splashing out and deflecting the air on to the falling water. The average ground space occupied is one square foot for every 60 gals. of water cooled per hour. One advantage of this type is that the vapor carried off is set free at a considerable height above ground level, and is not likely to cause a nuisance.

Underground Chimney Coolers, Natural Draft.—Of the same construction as a tower cooler, but is sunk into the ground. By this arrangement the water from jet condensers will flow to the distributing troughs by gravity, and will in time be drawn from the reservoir into the condensers by the vacuum. The foundations of these towers are very costly to construct, there being a large amount of excavation and concreting necessary. An underground cooler occupies more ground space than an above-ground cooler for equal duty, averaging 30 gals. of water cooled per hour per square foot of ground surface.

Open Coolers.--These consist of a water stack only with the usual reservoirs under. All round the water stack louvre boards are fitted to prevent the water from spraying out and to deflect the air. The ground space occupied is slightly less than an underground cooler occupies, but more than that of a chimney cooler, the average duty being 38 gals. of water per hour per sq. ft. of ground surface. A serious disadvantage of this type is the necessity of building same well in the open, as any obstruction to the wind blowng into them seriously reduces their capacity. The efficiency of these towers will vary by 20%, according to the velocity of the wind. These towers can also create a nuisance if not screened from a public highway. This is the only type of tower that can reduce the temperature of the water below that of the surrounding air, and is very much used for ice machinery.

Fan Coolers are of exactly the same con-

struction as the chimney type, but, in place of louvre boards for air, inlets are fitted with one or more fans. Fans, while consuming a considerable amount of power (about 2% of total engine output), are very flexible, and are useful on varying loads. Fan towers should never be erected where there is room for other types.

Size of Tower.—As previously mentioned, all cooling towers operate on the principle of air being capable of absorbing water, every pound of water evaporated and carried away absorbing 966 latent heat units. There is also a certain amount of heat absorbed by the rise in temperature of the air. The amount of vapor absorbed varies with the dryness of the air, but in England the air can generally absorb 5% of its own weight. Assuming a 1,000-KW. power plant to be equipped with reciprocating sets, the over-all steam consumption on peak load being 35 lbs. per kilowatt, a tower to deal with 600-KW., or 21,000 lbs. of exhaust steam per hour, is a useful sized unit. Assuming the station will increase 200-KW. per annum, in two years' time another tower of a similar size should be installed. As the output increases the kilowatts connected per annum will also increase, and the size of units installed will be of much larger size. Steam condensed per hour equals 21,000 lbs. Each pound of steam condensed will add 960 B. T. U. to the circulating water. 21,000 × (say) 1,000 in place of 960-066= 21,000,000 units to be dissipated by the tower per hour. As a pound of air can absorb 5% of its own weight of moisture, each pound of air (which equals 13 cu. ft. normal) will carry off 1,000 B. T. U. × 0.05=approximately 50 B. T. U. per pound of air. The total cubic feet of air required can now be calculated:

$$\frac{21{,}000{,}000 \text{ units per hour, total}}{50 \text{ units absorbed per pound air}} = 420{,}000 \text{ lbs. air per hour.}$$

Assuming an efficiency of 75%.

420,000 × 0.75 × 13=4,100,000.

4,100,000÷60=685,000 cu. ft. air per minute.

If a fan tower is installed, the ground space occupied will be about 215 sq. ft. The fans will absorb approximately 18 B.H.P. If a natural-draft tower, above ground-type, the ground space occupied will be about 950 sq. ft. The lost water in each case is equal, and practically amounts to the quantity of feed water.

THE FIRST AMERICAN GRAMME RING DYNAMO

By G. S. MOLER

FROM "THE SIBLEY JOURNAL OF ENGINEERING."

The Gramme Dynamo which is illustrated herewith, and which is shown as being mounted upon a Brackett cradle dynamometer, was built in 1875, in the Sibley shops by Prof. William A. Anthony assisted by the writer. It was the first Gramme ring dynamo ever built in the United States and it was also the first dynamo ever owned by Cornell University. It has been in actual use perhaps for a larger total number of days runs than any other dynamo or motor in this country.

The dynamo was constructed for the Department of Physics and has been used by that department either as a dynamo or motor ever since it was built. At present it is doing excellent duty as a motor, driving the machinery of both the mechanician's and the student's shops in the south basement of Rockefeller Hall.

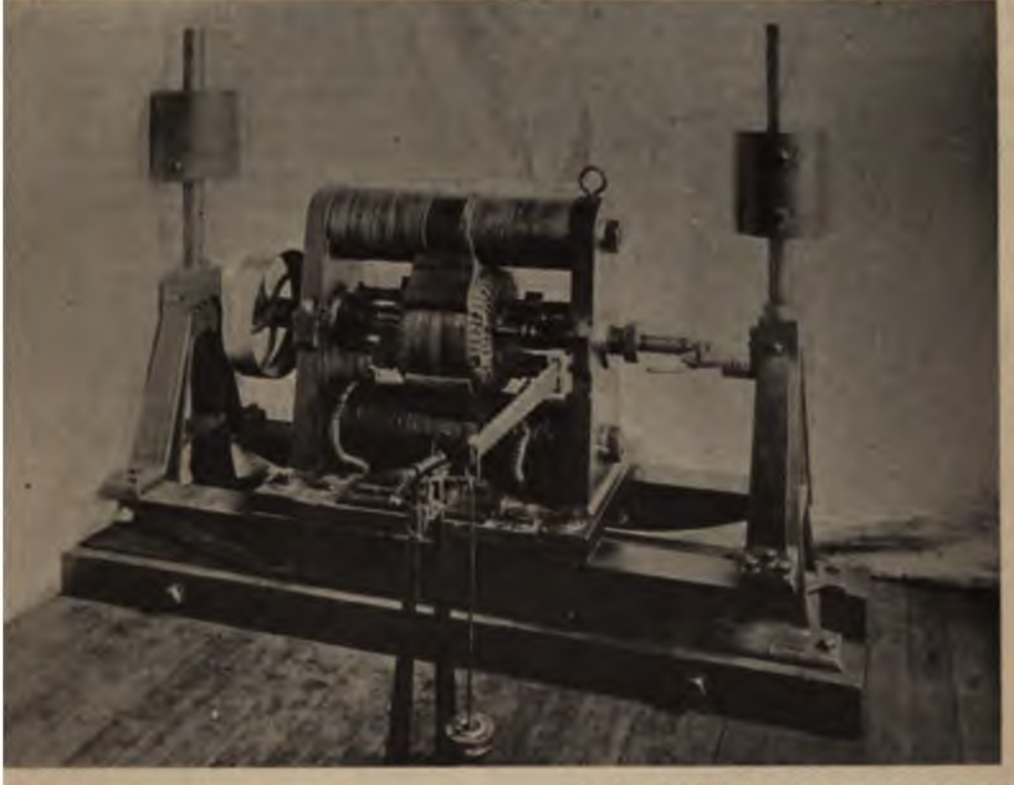
The machine was copied in a measure from the French Gramme dynamos which were being built about 1875, but there are a few features which were introduced by ourselves, the principal one being the movable rocker arms for the brush holders. That device, which is now so universally employed, was used by Prof. Anthony and the writer upon this dynamo for the first time. There are two independent sets of windings upon the armature but there are no connections between them. Each set has its own commutator, and at first roller switches with contact springs were pro-

so that either could be used alone or ould be connected in parallel or in

n the dynamo was first built square as used in its construction and only pon the armature was provided with ring. The square wire was chosen so e cross-section of each turn might be greater without increasing the space to the windings, but it was found that

tended only for series use, were carried to a long roller switch which was so designed that it would give six different groupings of those circuits, from all in series to all in parallel.

The behavior of the dynamo with the square wire upon it was not very satisfactory so it was all removed and round wire was substituted. In those days it was not easy to procure covered magnet wire, so bare wire was purchased and then after converting a lathe



Courtesy of "The Sibley Journal of Engineering."

THE FIRST AMERICAN GRAMME RING DYNAMO.

uare corners of that wound upon the re were continually cutting through ulation causing short circuits.

of the four magnet spools had eight ndent circuits upon it, the whole being ayers deep and each layer forming one circuits. These were wound in such a to practically have the same number pere turns and the same resistance in ayer. Bare wire was used on these and it was spaced so that the turns ot in contact, the spaces between the then being filled with shellac. These wo magnet circuits, which were in-

into a covering machine all of the wire necessary for rewinding all parts of the dynamo was double cotton covered.

After the wire was changed the roller switches were removed and a plug switch for the magnet spools was substituted for them. The arrangement of eight circuits for each spool was also abandoned. The dynamo as finally remodeled and run as a series machine, gave twenty amperes at about seventy-five volts from each commutator when being run at about eleven hundred revolutions per minute. By putting the two commutators in series 20 amperes at 150 volts were obtained and by

means of this five 20-amp. 30-v. Weston arc lamps were run for lighting purposes.

One of the first uses requiring steady running was for making oxygen and hydrogen for the lanterns of the University. However, a plant was soon constructed for making the above gases by electrolysis and the dynamo was then moved over to Sibley Hall and connected to the power driving the shops. It was very soon found that a series dynamo was not suitable for driving an electrolysis plant, for, when the power slowed down, the counter electro-motive force of the cells caused a reversal of the magnetism of the dynamo, and upon speeding up again the direction of the current through the plant was again reversed, thus causing a mixing of the gases. To overcome this difficulty a small Weston dynamo was purchased and used as an exciter. This Weston machine was one of the very earliest and shunt-wound dynamos ever built. The date of its purchase was used in the courts to establish the priority of certain patents upon shunt-wound dynamos.

The dynamo was exhibited in 1876, at the Centennial Exhibition in Philadelphia, where it was driven by a straight line engine which was also one of the products of the Sibley shops. It was again exhibited at the World's Fair at Chicago, in 1893 and also at the Universal Exposition at St. Louis, in 1904. At Chicago and at St. Louis it was exhibited as a historical piece and at the latter place silver medals were awarded in appreciation of its historical value, to Prof. William A. Anthony and G. S. Moler, builders of the dynamo, and to Dr. E. L. Nichols, Director of the Department of Physics, Cornell University.

LIQUID FUEL FOR INTERNAL-COMBUSTION ENGINES*

By R. W. A. BREWER

The use of the term "liquid fuel" in this paper implies that the fuel is supplied to the engine in a "liquid" as distinct from a "gaseous" state. It does not necessarily follow that the fuel enters the engine cylinder in a liquid state.

Heavier Oils. In order to successfully utilise a liquid in the form of oil in the cylinder of an internal-combustion engine, two distinct methods have been tried to cope with the difficulties present. The fuel can be introduced: (1) As oil, without chemical change, either in an atomised or partly-vaporised and partly-atomised form; (2) with chemical change such that the oil before entering the cylinder has been wholly or partially decomposed into the lighter hydrocarbons.

In case (1) may be classed the first commercially successful engine, the Priestman, although in its effect it borders on case (2). The paraffin was injected by means of a nozzle into a [illegible] under normal working conditions. The [illegible] of the spray being to [illegible] the heat of the chamber and the rapidity of compression convert the spray into a smoky vapor, which burns when mixed with its correct proportion of air. In this type of engine the compression is comparatively small, as a large compression would render the mixture unstable and liable to pre-ignition.

Distinct from this type is the Diesel engine, which works by compressing the air alone up to about 700 lbs. per sq. in. Into this highly-compressed air at the end of the inward stroke of the piston is injected the correct proportion of liquid fuel, by means of air at a higher pressure operating a jet. As this fuel enters the cylinder it burns spontaneously, without a sudden rise of temperature, throughout a greater part of the working stroke.

Finally, there is the Roots type of engine, which has the low or ordinary compression of about [illegible] lbs. per sq. in., in which each charge of oil is accurately measured, and injected into the engine cylinder during the suction stroke, and in which chiefly atomization is relied upon to produce proper carburation of the air in the cylinder.

Under type 2 come all engines having ex-

* [illegible] the Society of Engineers.

heated vaporizers, in which the liquid first converted, by partial decomposi-o a gaseous or semi-gaseous state be-introduction into the engine cylinder. cal change takes place in this vapor-l there is always the likelihood of de-f carbon or heavy residuals forming any possible variation in temperature the vaporizer and the induction pipe se the vapor to condense in the pipe id the inlet valve before it reaches the

ffect of such an action may not be rked in a stationary slow-speed engine at constant load and speed, but when nditions vary, the whole system may ecome deranged, owing to the small e range of a mixture of air and oil o that when an oil engine is designed ying loads and speeds, such as for r work, the following points are to dered:

il-feed must be accurately measured. xact proportion to the air admitted at s—any system of governing by throt-e air inlet must act upon the feed of e same proportion.

ay carburetter cannot give satisfaction l is utilized, as the action of a jet is portional, and there must of necessity at variation of the feed in such a de-his variation will occur not only for orking strokes in which the volume of duced by throttling, but also when the is full open and the supply of air un-ed.

; to the small explosive range in the oil, either more or less vapor than that to produce the best results will cause ire, which will be followed by one or hers, resulting in the stoppage of the Usually about 20% of the total cyl-olume contains inert or burnt gas at of a charging stroke when the engine correctly. But when an explosion is the next charge is richer (perhaps too ire), owing to the absence of this 20% gas. An absolutely positive, accu-easured, and mechanically-controlled oil is therefore a necessity in this type ne, and this feed must be delivered orking stroke. The volume of oil re-o carburate free air is so very small 2.5% by volume) that the chief diffi-encountered in producing an apparatus tly sensitive and at the same time one ll stand the wear and tear to which apparatus is subject.

The Lighter Petroleum Distillates.—It is about ten years since the lighter fractions distilled from petroleum came into commercial use as a fuel in this country. The same high-speed engine, such as is the prime mover in the majority of motor-cars of the present day, was at that time in a state of infancy, and liable to frequent breakdowns through small derangements. It was a necessity that the fuel for such an engine should be of the simplest nature, as far as its manipulation and properties for carburation were concerned.

Distillers of these lighter fractions know well that the majority of failures and breakdowns in the early days of the motor-car were attributed to the imaginary, or real, bad qualities of the fuel. This light fuel had originally a specific gravity of 0.680, and was very volatile, as the type of carburetter then employed depended solely upon the volatility of the spirit to effect its purpose. The spirit of 0.680 specific gravity here referred to might be considered to be hexane, as it was a mixture of this compound with the higher and lower members of the saturated hydrocarbons, and was represented by the formula C_6H_{14}.

The earliest types of carburetter for this spirit consisted of a small tank containing the fuel, the necessary air being drawn over the surface of the fuel and thus becoming carburated. Later forms were fitted with wicks dipping into the fuel in order to avoid splashing and erratic behavior of the liquid. This wick type of carburetter exists at the present day in a modified form, but it is obvious that as volatility is alone depended upon to effect the carburation, only the lighter fraction can be used.

The jet spray types of carburetters now generally in use are semi-mechanical in their action, and when dealing with petrol of a specific gravity of 0.720 can be made to give a certain amount of satisfaction, at any rate to control the proportions of petrol vapor to air within the limits of ignition throughout a large range of demand. This spirit is usually employed at the present time, and the ratio of carbon to hydrogen is nearly represented by C_7H_{16} (heptane).

Spirit of Greater Density.—The specific gravity of the spirit alone is no true measure of its suitability for use in an ordinary jet-spray carburetter, but it is the range of boiling points, as observed in a distillation test, which determines the true value of any particular spirit.

The Fuels Committee of the Motor Union points out in its report how spirit of a high

specific gravity has been excluded in the past from our markets by an erroneous standard, but the thermal value per unit weight of Borneo spirit is higher than that of the spirit now generally in use, and it contains slightly more carbon in its composition. The author has found as a result of numerous experiments with this fuel an increase of 10% in its effect in a motor-car engine as compared with American spirit of 0.715 specific gravity. This spirit must not be confused with a paraffin, as it evaporates completely at ordinary temperature without leaving any oily residue.

Pennsylvanian spirit has a composition of 84% C, 16% H, with boiling points between 60° and 150° C. Paraffin consists of 85% C, 15% H, has boiling points between 150° and 300° C, and has a flash point now below 23° C. Borneo spirit of a specific gravity of 0.760 consists of 91% C and 9% H, and distills completely between 60° and 150° C.

Even a heavier spirit up to 0.780 specific gravity, though its range of boiling points be increased in an upward direction, contains a proportion of lighter fractions which carburate air without the application of heat. In its action, therefore, it is distinct from paraffin, as the engine can be started cold, and the greater ratio of the explosive mixture makes it possible to run the engine until the parts become sufficiently warm to effectually carburate the heavier fractions present in such a fuel.

The Borneo spirit of 0.760 specific gravity is very similar in its volatility to the better-known light American (Pratt's) spirit, the only real difference being in the greater percentage of carbon present in the former. This higher percentage of carbon is due to the presence of benzol.

The author's experiments in connection with petrols of high specific gravities have been confirmed by later tests made by others interested in the development of the internal-combustion engine. The object of the trials was the observation of the relative behavior of the different fuels under road-running conditions, and tests were made over long distances varying from 1,000 to 2,000 miles, and also over shorter distances upon level roads - taking units of one pint, or one gallon of fuel, in each case, and noting the distance covered by the car upon such a fuel allowance.

The chief features noticed were: (a) Consumption in gallons per hour = C; (b) miles traveled per gallon = E; (c) speed of car in miles per hour = V; (d) approximate weight of car and passengers; (e) condition of road; (f) behavior upon the level; (g) hill climbing.

Naturally, in tests of this nature, the conditions varied enormously, and a general average had to be struck, and the results deduced from an empirical formula constructed by the author for the purpose. A variable Y, with a standard equal to unity, has been introduced for the purpose of taking into account the observed conditions of the road surface and load, before placing the various fuels in their relative positions in the table.

In the construction of the formula, see Table I., the author assumed that the useful effect of each fuel was proportional to E, the miles traveled per gallon; also to V the velocity of the car in miles per hour, and inversely proportional to the rate of consumption = C. As the speed did not vary to any marked degree, any error due to the assumption of V is slight, but the results agree very well with those of the general observation upon the road.

V^2 was taken, as the author has found by experiment that above a certain speed the power required to propel similar cars against the air and other resistances varies approximately as the square of the velocity. For instance, it required 10 HP. to propel a certain car at 30 miles per hour, whilst a similar car required 20 HP. to propel it at 40 miles per hour. The road and axle resistance given by Col. Crompton for certain cars being constant at about 49 lbs. weight, whilst the total air resistance was about 77 lbs., when it was reduced to a minimum at 39 miles per hour.

Table I.—Tests of Liquid Fuels. Petroleum Products. Long Tests.

	(1) Sp. Gr.	(2) $\frac{E\,V^2}{C \times 1000}$	(3) Y	(4) Col. (2) x Col. (3).
Borneo	0.760	11.6	1.1	12.4
Pratt's 0.715...... / Paraffin 0.810....	0.755	10.0	1.0	10.0
Borneo 0.760...... / " 0.780......	0.770	7.4	1.3	9.6
Pratt's	0.715	9.5	1.0	9.5
Borneo	0.780	6.85	1.2	8.9

Vaporization and Explosive Mixtures.—Refined petroleum is a complex mixture of hydrocarbons of various boiling points. In evaporation at temperatures below the boiling point such particles as escape from the surface of the liquid exist as vapor. In the case of any of the ordinary petrols, either of the light or heavy variety, evaporation continues at ordinary temperatures until the whole has disappeared without leaving an oily residue.

The proportion of hydrocarbon vapor which the air takes up varies with the volatility of the petrol and the humidity, pressure, and

temperature of the atmosphere. For instance, dry air will take up the following quantities of vapor from petrol having a specific gravity = 0.650.

17.5% by volume at 50° F.
27% " 68° F.

before the air is saturated. These percentages are equivalent to

1 vol. vapor to 5.7 of air at 50° F.
1 vol. vapor to 3.7 of air at 68° F.

showing that a small increase in the temperature largely increases the percentage of petrol vapor which can be retained by the air. Petrol of a specific gravity of 0.700 containing 83.72% C and 16.28% H has a vapor density of 0.24 lb. per cu. ft. at atmospheric pressure when at a temperature of 32° F., or nearly three times the density of air.

With regard to the open evaporation of petrols of various densities and chemical compositions, the author has made a number of experiments in order to determine the effect of temperature and air currents upon the time taken to effect complete evaporation. The apparatus consisted of an electrically-driven fan with speed controller, anemometer, a portable furnace, and a thermometer. Air currents of different velocities were passed over thin strips of paper saturated with the different fuels, and the time noted when the liquids had completely disappeared.

The results are given in Table II., and clearly show that although at ordinary temperatures there is a marked difference in the time taken by the petrols of the highest and lowest specific gravity, the application of heat makes the behavior more nearly alike than does the effect of air currents alone. It also shows that although the chemical compositions of the Borneo spirit of 0.760 specific gravity and the spirit of 0.720 specific gravity are dissimilar, yet owing to the similarity of the distillation tests of the two, the time taken for evaporation in this way is practically the same.

The deductions made from such tests lead one to expect that when comparing the Shell spirit of 0.720 specific gravity and the Borneo spirit of 0.760 specific gravity, no perceptible difference will be experienced when starting an engine cold, and that the behavior of the engine in traffic, as far as flexibility is concerned, will be the same with either fuel. But when comparing the spirit of 0.780 specific gravity (which contains fractions having a higher boiling point) and the other two spirits, we find that the former requires assistance in the form of heat to accelerate the action of the vaporization. This heat can be added in the following ways. Either the carburetter itself or the incoming air can be heated by the exhaust, when the ordinary types of carburetter are employed, or the spray of petrol can be mechanically broken up in order that such fractions as do not readily vaporize may be carried in suspension into the engine cylinder itself. If no precipitation takes place in the induction pipe, the whole of these heavier particles at once vaporize during the compression stroke. When a carburetter of the suction-spray type is employed, this atomization can only be perfectly carried out when the engine is kept running above a speed high enough to produce sufficient suction at the jet. It may, however, be expected that a good mechanical carburetter would deal more satisfactorily with a heavier petrol than the 0.780 specific gravity here specified.

Table II.—Evaporation Tests.

Velocity of Air in Feet Per Minute.	Temperature of Air in Degrees Fah.	Specific Gravity of Petrol, Shell, and Borneo.	Mean time of Evaporation in Seconds.
Still	58	0.720	30
		0.760	35
		0.780	90
300	59	0.720	22
		0.760	26
		0.780	40
240	95	0.720	15
		0.760	17
		0.780	27
350	100	0.720	14
		0.760	16
		0.780	25
350	160	0.720	9
		0.760	9
		0.780	17
500	95	0.720	12
		0.760	12
		0.780	18

In order to form an explosive mixture with a fuel of this nature, knowing its chemical composition, it becomes a simple matter to ascertain the correct quantity of air required to effect complete combustion. The proportions must be such that the propagation of the flame is sufficiently rapid to produce an explosion.

Taking a Borneo spirit of 91% carbon and 9% hydrogen, 1 lb. carbon requires 11.6 lbs. of air for its complete combustion—

$\therefore 0.91 \times 11.6 = 10.5$ lbs. of air for the C.

One lb. hydrogen requires 34.8 lbs. for its complete combustion—

$\therefore 0.09 \times 34.8 = 3.14$ lbs. of air for the H.

Hence, theoretically, the total air required 13.64 lbs., which at 62° F. = 182 cu. ft. at atmospheric pressure. In practice, we find the excess of air admitted greatly dilutes this mixture, and that instead of a mixture containing 1.8% of petrol vapor, the vapor is diluted with 60 or 70 times its own volume of air, i. e., the percentage of petrol is only 1.6 or 1.43.

The investigations of Sir B. Redwood upon the limits of explosion of mixtures of petrol vapor and air show that when using a petrol of 0.720 specific gravity, and firing the mixture in a closed vessel by means of a naked flame, the most explosive mixture consisted of 1.86% of petrol vapor. With a petrol of 0.680 specific gravity these figures become 2.5%, as is shown in Table III.

Table III.—Specific Gravity of Petrol 0.680 giving 190 to 200 times its own Volume of Saturated Vapor.

	Per Cent. by Volume of Petrol Vapor.
No ignition with	1.075
Silent burning with	1.345
Sharp explosion with	2.017
Violent explosion with	2.352
Less violent explosion with	3.362
Burning and roaring	4.034
Burning silently	5.379

The most violent explosion occurred when 12.25 vols. of liquid were mixed with 100,000 vols. of air. These experiments were conducted without a previous compression of the mixture, and it is chiefly owing to this compression in an engine cylinder that such weak mixtures as are used in modern practice can be made to explode.

The author has made many tests on the road with a view to ascertaining the minimum strengths of explosive mixtures used in his motor-car, the engine of which has four cylinders, each 90 mm. diam. by 110 mm. stroke, and observations were made as to the rate of consumption, etc.

Petrol consumption, one gallon per 20.5 miles. One gallon was consumed during 38,-700 engine revolutions = 77,400 cylinder charges of mixture.

Each cylinder volume swept by piston = [illegible] c.c.

One gallon of petrol = [illegible] c.c.

Taking a carburetter loss of 15%, petrol used = [illegible] c.c. per [illegible]

[illegible] at 14 lbs. per square inch absolute and [illegible] F. = [illegible] [illegible] million c.c. at [illegible] lbs. per sq. in. and 62° F. That is [illegible] vols. [illegible] per 100,000 vols. of mixture [illegible] of Borneo spirit of 0.760 [illegible] the figures given by authorities on the subject for the best proportions are with 0.680 specific gravity, 12.25 vols. liquid to 100,000 vols. air theoretically and without compression.

The test figures show for Borneo 0.760: 59 vols. of air to 1 vol. of vapor = 1.7% of petrol vapor, as against 4.0 vols. air to 1 vol. vapor = 2.5 theoretically for the 0.680 spirit, and for 0.722 specific gravity spirit = 1.86% theoretically.

From the above figures it is evident that the proportion of petrol to air is high, and that either more air could have been used or the assumed loss of 15% in carburation is too low.

Benzol.—When we look for a substitute for petrol, a home-produced fuel, which can be utilized without in any way altering the existing arrangements of the engine or carburetter, undoubtedly holds out great hopes. Such a fuel, known as benzol, is a distillate of coal tar, or can be extracted from coal gas. It is a light hydrocarbon, C_6H_6, and is a clear liquid similar in appearance to petrol, but having a slight smell of sulphur, due to the presence of about 150 grains of sulphur compounds per gallon. The specific gravity of pure benzol is 0.885, boiling point 80° C. or 176° F. Total evaporation point of crude benzol 145° C. or 293° F., and one gallon contains 163,680 B.T.U. of heat, as against 157,142 B.T.U. for petrol, and has an explosive range from 2.7 to 6.3%.

The largest source of supply is from coke ovens or gas works. In the modern systems of coke manufacture for iron smelting the by-products obtained in the distillation of coal are collected instead of being allowed to go to waste, as in the old style of beehive oven. The benzol obtained in the gases from distillation is readily absorbed by means of suitable oils, from which it is afterwards extracted by distillation.

Commercial "90% benzol" is a spirit of which 90% evaporates in a retort at a temperature of 120° C., and the production of which amounts to about 5,000,000 gals. per annum in this country. This supply could be largely increased by the installation of suitable recovery plant, should the demand warrant this expenditure. The supply could thus be [illegible] within a very short time. The present price of this fuel when refined is about [illegible] per gallon at the makers' works, the process of refining and washing costing about [illegible] a gallon. The process of washing by means of sulphuric acid and soda partially eliminates the sulphur compounds,

hed benzol might be made suitable -car work by distilling out the :tions, and with them the bulk of ties.

gard to the use of 90% benzol as a the author has made a number of s, the results of some of which are w, and can be compared with those given for petrol of various den-

	Miles per Gallon.	Distance.	$\frac{EV^2}{C \times 100}$	Y
Long Test.				
grav. 0.875	27.2	116 miles	14.8	1
Short Test.				
"	24	14 miles	12.25 in traffic	
"	22	15 "	12.4 "	

ances traveled per gallon compare ably with the best results obtained l, viz.:

ecific gravity, 18 miles per gallon.
" 21.5 "

pulled well, and the speed of the ept about the same as when using

ıor finds that on some occasions it e to use rather a larger jet with n with petrol, but care must be dmit sufficient air, or sooting takes e the cylinder. The smell of the the unburnt state is slightly more in the case of benzol, but the ex- s have little smell and no tendency

—In spite of what has been said cohol as a motor fuel, it is the pinion that alcohol has great possi- this direction.

The author has obtained samples of commercial methylated alcohol having a specific gravity of 0.833, and with them conducted a number of tests, using the other ingredients in varying proportions. He has succeeded in running his motor-car satisfactorily upon these mixtures and also with alcohol mixed with only 25% of another fuel.

Considering, now, these essential qualities, the properties of alcohol may be briefly summarized as follows: Ethyl alcohol C_2H_6O, a volatile colorless liquid with a specific gravity of 0.806 at 0° C. Calorific value about 12,600 B.T.U. per pound. Boiling point 78° C. Explosive range 4 to 13.6% with air.

Methylated spirit, consisting of 90% ethyl alcohol and 10% methyl alcohol (CH_4O), has a calorific value of about 11,000 B.T.U. per pound.

The following is an approximate comparison:

	Petrol 0.722	Methylated Spirit.
Calorific value in B.T.U. per lb	20,000 (gross)	11,000 (gross)
Net calorific value per lb., i. e., heat converted into work	4,248 B.T.U.	3,322 B.T.U.
Thermal efficiency =	21%	30%

In practice, a petrol motor rarely exceeds a thermal efficiency of 18%, whilst with an alcohol motor the highest efficiency is readily obtained, and, considering that a gallon of alcohol weighs about 12% more than that of the petrol, the net value per unit volume is about the same. A great advantage of alcohol is its uniformity of composition, the whole of the spirit distilling over at a temperature of about 78° C.

'HE ELECTRIC SMELTING OF IRON

FROM "THE MINING JOURNAL" (LONDON)

ell-known fact that our neighbor on side of the North Sea, Norway, is possessor of immense deposits of hough the statistics do not seem to ything of the kind, as the exports to the present time have been quite it.

on for this is, however, not difficult as the Norwegian ores have, as a ined far too much titanium to be r the present furnaces. However, ure places a poison, the antidote away, and the adage has just received a fresh illustration in the application of electric smelting with graphite as substitute for coal and coke.

The last experiments indicate that removal of the injurious titanium is not an impossibility any longer, and although the matter has not been demonstrated in practice as yet, there is no reason to believe that experiments on a large scale should turn out less successfully than on a small.

The inventor, Mr. Albert Hiorth, of Christiania, in the course of a lecture and demonstration of his process, recently said that ac-

cording to the official report of the Canadian Commission, a small 500-HP. electric furnace would successfully be able to compete with regard to the cost of production with the most modern American blast furnace, producing 300 tons per day, the cost of the latter being about $550,000, with 100 men to work it. He then gave a collection of tables showing the cost of pig iron per ton produced from 55% hematite ore, as follows:

(1) In electric furnace (Keller & Lefeux), $11.58 per ton pig iron.

(2) In American blast furnace, $10.90 per ton pig iron.

(3) In electric furnace at Norwegian waterfall, $9.48 per ton pig iron.

In comparison with above, the cost in a Hiorth induction furnace, worked by water power, and the graphite as a substitute for coke, would be per ton of pig iron from iron sand, about $7.65.

Dr. Heroult has by his latest experiments proved that even inferior ores can be reduced with advantage by electric smelting. Thus a good pig iron might be obtained even from pyrrhotite with 1.5% sulphur, as well as from titaniferous ores with up to 17.8% TiO_2.

After having given some results of the experiments made by Dr. Heroult, the lecturer then proceeded to point out the conditions and the possibilities of the smelting and refining of iron ores by means of electric smelting, and with power from the numerous waterfalls in Norway. Iron ore deposits as well as waterfalls were to be found, so to say, everywhere; but the great drawback for utilizing these sources of wealth up to the present time had been the lack of coal for the reduction. Previously charcoal had been utilized, and an excellent product had also been obtained; but of course now it pays better to use the forest for timber and pulp.

But even if electric furnaces were to be built along the coast, and the necessary coal imported, such an industry would most likely not be of any great stability; as those countries that now are exporting their coals, but are wanting iron ores for their own furnaces, soon would increase the prices of coal, so the production would become too dear, in spite of cheap power. The main thing was, therefore, to become independent of foreign countries for the supply of carbon, and during his endeavors to solve this problem the lecturer had been struck by the idea of utilizing the extensive deposits of graphite which are to be found in many places in the north as well as in the south of the country. Most of this graphite is so impure that it cannot be utilized at present, or, at any rate, only small quantities of it. Graphite is, as is well known, the heaviest and purest carbon existing, and shows especially a great stability towards chemical reactions.

During previous experiments he had, however, succeeded in producing carbide by smelting graphite with lime, and apparently with a very small consumption of energy.

It is generally supposed that graphite can be used for the manufacture of carbide, but that considerably more heat is required on account of its great stability, than by the use of coal. It has, however, been proved that in carbide the carbon exists in the form of graphite, and Acheson has proved that all carbon by heating is transformed into graphite. Thus the carbon used for manufacture of carbide has first to be transformed into graphite, which means use of energy. By a direct utilization of graphite this part of the energy therefore ought to be saved. Experiments proved that the reaction of carbide by smelting graphite and lime was very easy, for which reason it also was to be expected that graphite might be used for the reduction of iron ore as well, by means of which the problem of coal would be solved in the best way.

In ordinary furnaces 1 ton of coal is required for 1 ton of pig iron, while in the electric furnace only one-third of it is required, the smelting heat being produced by electricity. The price of 1 ton of furnace cinders delivered in Norway would be about $5.80 to $6.80 per ton. Graphite, delivered c. i. f. at most ports would cost only one-third of the cinders. The cost of carbon for electric furnaces, in comparison with usual furnaces, would consequently be reduced by $\frac{1}{3} \times \frac{1}{3}$, or 1-9 in all. The graphite existing can in many places be worked by quarrying, and thus be had at a very low cost, many of the deposits being situated close to the sea. In one case, for instance, graphite, iron ore, dumps of lime from marble quarries, and water power are found close to each other, which means that all transport practically would be reduced to a minimum.

Thus the lecturer pointed out the opportunities for manufacture of iron and steel were as advantageous as possible, and scarcely could be offered anywhere else.

Good pig iron can be obtained in the electric furnace, even from a very impure iron ore and graphite containing more than 30%

of silica or other impurities. In some places a treatment of the graphite would be recommended.

The following is the result of an experiment with smelting iron-sand containing 13% TiO_2 with graphite of a tenor of 68% C., lime being used as slagging material. In spite of the contaminations of these raw materials, the pig iron produced showed—

0.01% SiO_2 and traces of TiO_2.

The pig iron produced is thus practically free of all the impurities contained in the raw materials, the same being retained in the slag. From these experiments, carried on in a small scale, and the results obtained by Keller and Heroult on a large scale, the lecturer had reason to believe that an iron industry could be created in Norway; in any case, for the production of those 80,000 tons which are now imported. The better qualities of ore might still be exported as now, the electric furnaces being able to utilize inferior ores.

An additional advantage of the electric furnace is that small plants can successfully be worked, thus obviating the requirements of large capital, which are absolutely essential for working the present blast furnaces. This advantage is so much the more important in a country where capital is anything but abundantly present. If a great number of small plants were erected, they would eventually be able to take their supply later from the large mines, as Dunderland and South Varanger; and as the expensive briquetting process might be avoided, the economy of the electric furnaces would be still more increased in comparison with that of the blasting furnaces (probably 15% of the cost of the ore).

STORAGE BATTERIES*

By V. KARAPETOFF

CONDENSED FROM THE "ELECTRIC JOURNAL"

PROPERTIES OF STORAGE BATTERIES.

1. **Comparison to Water Storage Tank.**—Storage batteries (also called electric accumulators) are devices used for storing electrical energy, which may be delivered at a later time. The part which storage batteries play in the distribution of electrical energy is much the same as a water storage tank plays in water supply systems. Without the tank the pumps have to supply a variable demand; their capacity must therefore be sufficient for the maximum demand. Moreover they must be operated 24 hours a day; the power consumption is much increased and the efficiency consequently reduced, to say nothing of the excessive mechanical strains imposed by sudden variations of the load. A water tank of sufficient capacity remedies all this; the capacity of the pumps needs to be sufficient for the average demand only, and they may be operated at practically full load. When the demand is below the average, the excess of water pumped simply raises the level in the tank. When the demand is above the average, the tank supplies the necessary excess of water to the mains. In addition to this the tank allows a more constant pressure to be maintained in the mains even with variable flow.

2. **Regulation of Load and Voltage.**—Similarly, in an electric power house without storage batteries the generators have to supply the variable demand and are subjected to all the disadvantages resulting therefrom, viz.: their capacity must be sufficient for the heaviest overloads which may occur; the machines must be operated 24 hours a day or at least as long as there is even the smallest demand for light and power; the engines are subjected to severe mechanical strains and are working under the most unfavorable conditions, as far as efficiency is concerned—namely at variable load.

When a storage battery is connected in parallel with the generators the latter need have a capacity sufficient only for the average daily load, and may be worked practically all the time at this load. When the load is below normal, the excess energy is sent into the batteries, charging them. At the hours of maximum demand (peaks of the load) the battery discharges into the line in parallel with the generators. During the hours of very small

*From a lecture before The Electric Club, Pittsburg, March 25, 1907.

demand the engines may even be shut down, the battery alone supplying the current. The efficiency of the plant is thus increased, and a steadier pressure maintained with fluctuating loads.

The limitations which at present prevent the universal use of storage batteries are: their comparatively high first cost and depreciation, additional complications resulting from extra apparatus needed for controlling and charging the batteries, and the amount of care required in their maintenance. There are many cases, however, especially in city electric railway work, where the advantages gained by the use of batteries by far outweigh the disadvantages; in such cases storage batteries are extensively used.

3. Construction and Chemical Action of Storage Batteries—An electric storage cell is a voltaic couple, in which plates of sponge lead (Pb) and peroxide of lead (PbO_2) are used as active materials. These plates are immersed in dilute sulphuric acid (H_2SO_4) which acts as an electrolyte. When the battery discharges, both active materials are partially converted into lead sulphate ($PbSO_4$), and the acid becomes more dilute. On charging a reverse action takes place; the plates being again reduced to lead peroxide (positive plate) and spongy lead (negative plate). The specific gravity of the electrolyte increases to its normal value, and the battery is again ready for discharge.

These chemical changes may be represented by a formula, thus:

$$\begin{array}{c} \textit{charge} \\ \longleftarrow \\ PbO_2+Pb+2H_2SO_4=2PbSO_4+2H_2O. \\ \longrightarrow \\ \textit{discharge} \end{array}$$

In reality the chemical reactions are much more complicated and hardly known at present in all details. The above fundamental equation is, however, sufficient for a general understanding of the operation of storage batteries.

Impurities in lead and in the electrolyte produce local chemical action which may ruin the plates. It is important, therefore, to use pure materials. The manufacturers insist in particular that chemically pure sulphuric acid and distilled water be used.

There are two types of battery plates, called the Planté type and the Faure type, after their respective inventors. In the Planté plates the active materials, spongy lead and lead peroxide, are "formed" on the plates themselves by successive charges and discharges, or chemically.

In the Faure or "pasted" plates the active materials are applied mechanically to a supporting grid. This grid is of lead; it supports the active materials and conducts the current to the terminals. The pasted materials usually require some formation by electrical or chemical processes before they are brought to their final form.

4. Voltages on Charge and Discharge.—A storage cell has an e. m. f. of a little over two volts on open circuit. If allowed to be discharged indefinitely the voltage will at first remain practically constant at about two volts, then will gradually fall off, at first slowly then more and more rapidly down to zero. The voltages given in the curve are to be measured while a normal discharge current is flowing through the cell. The voltage drop is due to the internal resistance of the cell and to some polarization on the surface of the plates.

A complete discharge down to zero voltage would be impracticable, because for all ordinary purposes the terminal voltage of the battery must be constant within rather narrow limits. Moreover, such a complete discharge would ruin the battery. The reason for this is that lead sulphate, $PbSO_4$ which is formed during discharge is practically an insulator, and if too much of it is allowed to be formed on the plates, the reduction back to Pb or PbO_2 is very difficult, if not impossible. Enough lead or lead peroxide must remain on the plates to keep down their resistance. Otherwise charging current cannot flow through the active material and effect a regeneration of the battery. In practice it is considered that the battery requires a new charge when the voltage has dropped to 1.75 volt. (or better 1.8 volt.) This voltage is measured with the battery supplying a current which corresponds to the eight-hour rate of discharge.

When the battery is being charged, the external voltage applied at its terminals must be high enough to overcome the counter-e.m.f. of the cell and to force the charging current through its ohmic resistance. At the beginning of a charge the charging voltage is a little above two volts per cell. As the battery becomes recuperated this voltage must be gradually increased, it being necessary to apply about two and six-tenths volts at the

end of the charge in order to get full charging current through the cell. The end of the charge is also recognized by an excessive liberation of gases (boiling) due to a decomposition of water in the solution.

The best indication, however, of a complete charge is that the specific gravity of the acid reaches its maximum and remains constant. Referring to the fundamental chemical reaction, given in section 3, this means that all sulphate is liberated, and the plates consist of pure lead and lead peroxide.

5. Capacity of Storage Batteries.—The capacity of a cell, or the amount of electricity that it can give on discharge is measured in ampere-hours; a cell which can supply 25 amperes for eight hours, before the lower limit of the e.m.f.—1.8 volts (or 1.75 volts for some makes)—is reached, is said to have a capacity of $25 \times 8 = 200$ ampere-hours. Experience shows that the capacity of a cell depends essentially on the rate of discharge. The more rapid the discharge the less is the capacity; thus the above cell if discharged at a rate of 100 amperes would be completely discharged in one hour instead of two hours. Therefore, in speaking of the capacity of storage batteries it is always necessary to mention the number of hours in which the battery is supposed to be discharged. It is customary to rate stationary batteries on the basis of an eight-hour discharge, and batteries used on electric automobiles on the basis of a four-hour discharge. Storage batteries used in electric railway sub-stations for taking up fluctuations of the load are usually rated on the arbitrary basis of one-hour discharge.

If a battery is intended to be discharged within a shorter period of time than the normal period, its rated capacity must be reduced in a ratio usually given by the manufacturer. Roughly speaking, if the capacity is 100 per cent. at an eight-hour rate, it is about 93 per cent. at a six-hour rate, 75 per cent. at a three-hour rate and only 50 per cent. at a one-hour rate. (See table in §7.)

One of the reasons for a decrease in capacity at higher rates of discharge is that the electrolyte cannot circulate as rapidly as required, thus diluting the acid in the pores of the plates, before fresh acid can take its place. Another reason is that a layer of lead sulphate is formed on the surface of the plates, preventing further action.

6. Testing Storage Batteries.—The principal points to be investigated in the performance of a storage battery are:

(1) Behavior at discharge.
  (a) Variations of terminal voltage.
  (b) Variations of density of the electrolyte.
  (c) Influence of the rate of discharge on capacity.
(2) Behavior at charge.
  (a) Variations of terminal voltage.
  (b) Variations of density of the electrolyte.
(3) Electrical efficiency.
(4) Internal resistance.
(5) Weights and dimensions per ampere-hour output.

There are a few more practical tests, such as influence of temperature, loss of charge by local chemical action, durability in service, etc., which in spite of their importance cannot usually be performed in the short time allotted to students.

The tests above enumerated will now be described in detail.

7. Charge and Discharge Characteristics.—The cell under test must be fully charged before beginning the experiment on discharge characteristics. The end of the charge is best recognized by the density of the acid, which reaches its maximum and remains constant. The voltage also reaches its maximum and remains constant. The absolute values of density and voltage are usually given by the manufacturer of the cell, and may vary within certain limits.

The time of charging should not be less than three hours if the battery has been completely discharged. At a higher rate of charging, the electrolyte warms up and the liberated gases cause it to boil; with the result that active material is washed out of the plates and the useful life of the battery is thereby reduced. Below this upper limit the amount of electrical energy necessary for charging is essentially independent of the charging rate.

It should be well noted that the acid ought to have the prescribed density when the battery is fully charged. The density may be corrected by the addition of distilled water. This should be done only when the battery is fully charged and under no other circumstances.

After the battery has been fully charged, the switch is thrown over to the discharge side. The current is adjusted to the desired value and maintained at this value until the end of the discharge. The voltage on discharge drops rapidly at the beginning and at

the end of the discharge, and remains practically constant between. Therefore, readings should be taken every few minutes at tho beginning and end of the run; a few check readings are sufficient for the rest of the time. Read volts, density of acid (on a hydrometer) and temperature; stir the liquid before reading the hydrometer, so as to measure the true average density.

The constant current of discharge multiplied by the number of hours of the test to the time when the battery is considered discharged gives the ampere-hour capacity of the cell. This capacity, multiplied by the average voltage during discharge, gives the watt-hour capacity. The test may be repeated with various rates of discharge, and the influence determined which the time of discharge has on the capacity of the battery.

The following table gives the voltages at which the discharge should be stopped (for "Chloride" batteries):

Hours Discharge.	Final Voltage.	Relative Values of Current.	Relative Capacity in Amp. hrs.
8	1.75	1	8 (100%)
3	1.70	2	6 (75%)
1	1.60	4	4 (50%)
1/3	1.40	8	2 2/3 (33 1/3%)

In every case the voltage is to be measured with a discharge current flowing at the corresponding rate.

8. Cadmium Tester.—In order to ascertain the state of charge on both plates a cadmium tester is sometimes used. It consists of a stick of pure cadmium placed in the acid of the cell under test. It is well to have the cadmium protected by a hard rubber tube with perforations for the circulation of the acid. At the end of the charge the voltmeter must show about 2.45 volts, between lead peroxide and cadmium, and about 0.10 volts between the lead plate and cadmium. This is a more or less positive indication of the end of the charge. The voltage between the two plates is equal to the sum of the two readings:

$$2.45 + 0.10 \quad 2.25 \text{ volts.}$$

The same tester can be used to ascertain the end of discharge. In this case the voltages are + 1.95 and − 0.20 volts respectively, and the battery voltage is

$$1.95 - 0.20 \quad 1.75 \text{ volt.}$$

In case it is found that one of the plates is not fully charged, the charge must be continued until the cadmium tester shows the required voltage. Or, if it is feared that an excessive charge may damage the other plate, the plate which requires additional charging may be charged in a separate cell. Such a cadmium tester gives reliable indications in the hands of an experienced observer, especially when many tests are made on batteries of the same type. Otherwise it is safer to judge of the state of the charge from the acid density and the voltage.

9. Internal Resistance.—The determination of the true ohmic resistance of storage batteries is rather difficult because this resistance is very small, is variable and is to some extent masked by the effect of polarization. Moreover, it is not the true resistance, but rather the virtual resistance of the cell that is interesting to the user, this virtual or equivalent resistance representing the total drop of voltage in the battery, due to whatever causes. The simplest method to determine the resistance R of a cell would be to observe the voltage E_0 on open circuit, and then immediately note the voltage E with a certain charging current I flowing through the battery. Then evidently

$$R = \frac{E - E_0}{I}$$

A better method is to measure two terminal voltages E_1 and E_2 corresponding to two different values I_1 and I_2 of charging current. Then

$$E_1 - p - E_0 = RI_1;$$
$$E_2 - p - E_0 = RI_2;$$

where p is the counter-e.m.f. of polarization. Eliminating p and E_0 and solving for R we obtain,

$$R = \frac{E_1 - E_2}{I_1 - I_2}.$$

An objection to this method is that the e.m.f., p, of polarization is not quite constant with various rates of charge. Another objection is that the difference $[E_1 - E_2]$ is rather small and this impairs the accuracy of the result. It is advisable to perform a large number of tests with various values of I_1 and I_2 and to take an average of the calculated values of R. Experience shows that more consistent results are obtained on discharge than on charge. The same formula is used as that given above.

Another way of measuring the resistance of a cell is the so-called "break" method which is considered by some to be more reliable. A certain value of discharge current through the cell is adjusted and when the conditions become steady, the circuit is suddenly opened. The pressure, as shown on the voltmeter, rises instantly a certain amount and then continues to rise gradually as the

polarizing bubbles of gas disappear. It may be assumed with a considerable degree of accuracy that the first (instantaneous) rise in voltage corresponds entirely to the ohmic drop, since the bubbles of gas are evidently the same as a moment before when the circuit was closed. From this rise in voltage and the current formerly flowing through the battery, the internal resistance can be calculated. Suppose, for example, that the voltage rises from 1.8 to 1.9 volt when the switch is opened, with 100 amperes flowing through the battery. The resistance of the cell is 0.1 ÷ 100 = 0.001 ohm.

10. Experiment A—Testing Storage Cells. —The experiment is performed as described in §§ 6 to 9. The readings during charge and discharge are taken at comparatively infrequent intervals; it is possible, therefore, to test simultaneously more than one cell. One voltmeter and one milli-voltmeter with several ammeter shunts are sufficient for all the cells. Some cells may be charging while others are discharging. Tests at low rates may be continued throughout several consecutive days by different observers, who may work out the results together.

At the end of the experiment measure all the dimensions of the cell and of its elements, so as to be able to make a drawing to scale. Determine the weight of the plates, of the electrolyte and of the complete cell. Do not keep negative plates out of the liquid longer than necessary; they may be damaged by the atmosphere.

OPERATION AND CONTROL OF STORAGE BATTERIES.

11. Selection of the System of Control.— Storage batteries are usually connected in parallel with generators. Auxiliary apparatus necessary for the operation of batteries comprises:

(a) Switches, circuit-breakers, measuring instruments, etc.

(b) Means for charging the battery, and for regulating its current and voltage on charge and discharge.

The apparatus (a) is similar to that used with direct-current generators; the devices (b) are peculiar to storage batteries.

Various methods are used for charging and controlling the output of batteries; the determining factors in the selection of a system of control being:

(a) The purpose of the battery.

(b) Its size.

(c) Permissible limits of current and voltage fluctuations.

(d) The cost of the system.

(e) Whether hand or automatic control is desired.

The most important systems of control in practical use are described in the follow paragraphs, beginning with the simplest system and including the most perfect automatic equipment.

12. Charging Two Halves of the Battery in Parallel—In the simplest method for charging and regulating storage batteries the battery is divided into two halves which are connected in series for discharging and in parallel for charging. This is done in order to secure a sufficient voltage for charging, without affecting the line voltage maintained by the generator. An example will make this clearer. Consider a battery intended for an ordinary 110 volt lighting circuit. The voltage of each cell at the end of discharge is about 1.8 volt; therefore the number of cells required is 110 ÷ 1.8 = 62. But the voltage necessary with this number of cells at the end of a charge is = 2.6 × 62 = 161 volts, which is far above the line voltage. With the battery divided into two halves in parallel only 80.5 volts are required for charge; the excess voltage of the line is taken up by the rheostat. Battery output on discharge is also regulated by this rheostat. This method, though very simple, is seldom used, except in small installations, where the loss of power in the rheostat is not objectionable.

A more economical method is to divide the battery into three equal parts; let them be denoted by A, B and C. The parts A and B are first charged in series for one-half of the time necessary for full charge; then B and C are charged in series for one-half of the time, and finally C and A for one-half of the time. Less energy is wasted in the resistances with this arrangement, although it takes longer to charge the battery. The voltage at the end of the charge is 2/3 × 161 = 107 volts.

Other combinations are also possible, for instance, A and B may be connected in parallel with each other and in series with C. The set is charged at the full rate until C is completely charged. Then C is disconnected, A and B are connected in series, and the charge is completed.

14. End-Coil Switches.—In many small installations there is no demand for current during the day. In such cases the battery is charged during the day, when the main switch is open,

the voltage on the generator being raised to the required 161 volts for charging the battery. During discharge the battery voltage and output are regulated by a so-called end-cell switch, by means of which more cells may be connected into the circuit in proportion as the voltage of each cell drops during the discharge.

End-cell switches are sometimes used in installations where charging is done by means of special machines which are called "boosters." Storage batteries in stations and sub-stations of the Edison illuminating companies in large cities are regulated by end-cell switches and charged by boosters. Large end-cell switches are sometimes operated by electric motors, which may be started or stopped either by the switchboard attendant, or automatically by a contact voltmeter.

The contact on the arm of an end-cell switch must be wide enough so that the battery circuit would not be opened while the arm is moved from one segment of the switch to the next. On the other hand, when the arm bridges two adjacent segments, the cell connected to these two segments is short-circuited, which is not permissible. Therefore the arm contact is made in two parts with a protective resistance between them, this resistance limiting the current in the short-circuited cell during the instant when the arm is moved from one contact to the next.

In some cases it is not practicable to have the main switches opened while the generator voltage is raised for the charge; at the same time the size of the installation does not warrant the complication of a booster. Two end-cell switches are used in such cases. By means of end-cell switch, the required voltage is maintained on the line, while the charge is regulated by the generator field rheostat and the other. With this scheme, the end cells are carrying the sum of the charging current and the line current, and are therefore charged faster than the rest of the battery. Actual practice does not show, however, any disadvantage in such an arrangement, provided the charging is done during the hours of small demand. It will be easily seen that more contact points are necessary with a double end-cell switch than with a single end-cell switch.

16. Floating Batteries—In plants in which considerable voltage fluctuations are not objectionable, or are unavoidable, storage batteries are often used without any means for regulating them, simply as floating batteries. This allows the battery to be freely charged or discharged with the fluctuations of the load. This system is used in some electric railway sub-stations, and also in plants containing cranes and elevators. The number of cells is selected so that when the generators give approximately the average output of the station, the voltage at the bus-bars is equal to the e.m.f. of the battery; under such conditions no current flows in or out of the battery. When the load is below the average, the generator voltage is higher than that of the battery, and a charging current flows into the battery. When the generator is carrying a rather heavy load, its voltage drops below that of the battery, and the battery discharges into the line, helping the generators (or rotary converters, if it is a sub-station). With such an arrangement the generator load is more constant than without the battery. The battery is never entirely discharged or fully charged, but is maintained in a medium condition. Once every few weeks it is necessary to raise the generator voltage and to give the battery a thorough charging and even an overcharge in order to prevent the formation of lead sulphate.

It is evident that such a floating battery is more effective when the voltage fluctuations are large. The voltage at the end of the feeders varies much more than in the sub-station, on account of the ohmic drop in the feeders; therefore it is better to have a floating battery at the end of the line. The advantages are—the average voltage being lower than in the sub-station, less cells are required; the fluctuations of the voltage being more pronounced, the battery is charged and discharged within wider limits; the load on the generators or rotary converters is steadier; there is a considerable saving in line copper, since the feeders have to carry the average current instead of the maximum current. The chief disadvantage of placing the battery at the end of the feeder is that extra room and attention is required outside the sub-station.

17. Battery Boosters—In addition to the cases described in §§ 12, 14 and 16 must large storage-battery plants are provided with so-called boosters, or extra generators for regulating the charge (and sometimes also the discharge) of the batteries. In the simplest combination the booster is driven by an ordinary shunt motor. The armature of the booster is in series with the battery, and the fields are separately excited across the bus-bars.

When the battery is discharging the switch is thrown up so that the booster is cut out of the circuit; the discharge is regulated by the end-cell switch. For charging the battery the switch is thrown down and the booster e.m.f. raised by means of the field rheostat; thus giving, together with the generator pressure, a voltage sufficient for charging. This voltage is regulated, as the charge progresses, by means of the same rheostat.

Instead of using an end-cell switch, the same booster may also be used for regulating the discharge of the battery. In this case a reversing switch must be connected into its field circuit, so that the direction of the induced e.m.f. may be changed.

Some companies connect the booster field across the battery and not across the line; there is not much difference in the two methods.

Shunt-excited boosters with hand regulation are satisfactory only in plants in which the load varies gradually and regularly, so that the battery can be charged and discharged during considerable periods of time. In railway service, where the load fluctuates within wide limits and where charge and discharge sometimes follow each other every few seconds, it becomes necessary to have automatic boosters whose e.m.f. is added to or subtracted from that of the battery according to the magnitude of the load.

There are two types of automatic boosters used at present—one in which the booster field is varied by the addition of compounding windings; another in which the current in the shunt field is regulated by suitable relays.

18. Differential Booster—This belongs to the first of the two types of automatic boosters mentioned above. It differs from the nonautomatic booster in that the end-cell switch is omitted, and the booster is provided with an additional series-field winding, which opposes the action of the shunt field winding. At a certain average load these windings neutralize each other, and the booster e.m.f. is zero. At this load the generator voltage must be made equal to that of the battery so that the battery neither charges nor discharges. At a heavier load the action of the shunt is stronger than that of the series winding, and the booster e.m.f. is added to that of the battery, assisting its discharge. On light loads the reverse is the case, and the booster tends to send a charging current into the battery. This action is entirely automatic, and the booster tends to maintain a constant load on the generators, the battery taking up the load fluctuations.

Experience shows, that in order to have this system work satisfactorily it is necessary to add a third field winding, acting in the same direction as the shunt field winding. This winding automatically corrects the voltage of the booster for the state of charge of the battery, as is explained below.

Suppose that the currents in the three field windings are so adjusted, that the booster e.m.f. is zero with the rated generator current and with the battery partly discharged. Then with the same load and with the battery fully charged, the battery tends to take more than its share of load, reducing the generator current. This reduces the current in the third differential winding and gives a preponderance to the shunt field of the booster. An e.m.f. is produced in the booster such as to oppose the e.m.f. of the battery and to prevent it from discharging.

On the contrary when the battery is nearly discharged and does not take its share of load, the generator becomes overloaded. Then an excessive current flows through the third winding and boosts the battery voltage, helping its discharge. In this way the third winding helps to keep the generator load constant.

19. Carbon-Pile Booster Regulator—One common drawback of automatic boosters provided with series fields is that the booster itself becomes quite large and expensive, since its frame has to accommodate three field windings. It has been sought, therefore, to have on the booster only the shunt winding and to provide outside the booster an additional device that would automatically vary the magnitude and the direction of the current in this shunt winding, according to the load. In a device of this kind, generator current, instead of passing through a series winding placed on the booster, passes through a solenoid. An iron core actuated by this solenoid compresses more or less, through a suitable leverage, two sets of columns consisting of carbon discs. These carbon piles are connected to the booster field and to the battery; the resistance of the columns consists chiefly of the contact resistance between the discs, and therefore varies within wide limits with the pressure exerted by the core of the solenoid.

With the normal value of the generator current the pressure on both piles is the same; their resistances are equal, and no current flows through the booster field. The whole

arrangement resembles the familiar Wheatstone bridge scheme, in which the booster field takes the place of a galvanometer. When the current is below or above normal one column is compressed more than the other, the bridge is not balanced, and a current flows through the booster field in one or the other direction, causing the battery either to charge or discharge. The arrangement is entirely automatic in its action, and takes the place of a booster with two or more field windings, tending to keep the generator current constant.

It would be too wasteful to have a current circulate all the time through the carbon columns, especially of such a magnitude as to be sufficient to energize the booster fields through unbalancing of resistances. Therefore, except in very small installations, the carbon regulator actuates the field of a separate exciter, which in turn supplies current to the field of the booster. The exciter being a much smaller machine than the booster itself, considerably less energy is lost in the regulator. The booster and the exciter are usually mounted on the same shaft and driven by a direct-connected motor.

20. Booster Regulation by Counter E.M.F.—Here the booster field is automatically regulated by a small counter-e.m.f. machine. The field of this machine is excited by the main current as was the solenoid A described in § 19. At a certain desired value of this current the counter e.m.f. of the machine can be made such that no current will flow through the booster field. When the generator current is below this value, the booster field is excited in such a direction that the battery is charged, and vice versa.

Formerly, the counter e.m.f. machine was direct-connected to the main booster set and driven by the same motor. Experience has shown, however, that the size of this machine can be considerably reduced driving it separately at a higher speed by a small motor. The size of the counter-e.m.f. set is still more reduced by introducing a second relay machine. Moreover, this arrangement increases the sensitiveness of regulation and permits the counter-e.m.f. sets to be made of the same standard size, with widely different sizes of batteries and boosters.

The counter-e.m.f. machine instead of acting directly on the booster field, acts on the field of a small exciter which in turn controls the booster field current. The armature of the counter-e.m.f. machine is connected in series with the exciter field, across the main busbars. When a normal current flows through the main generator, and consequently through the field series of the counter-e.m.f. machine, the voltage induced in the armature of the latter just balances the voltage across the bus-bars; consequently, no current flows through the exciter field, and the booster excitation is = zero. When the generator current is above the normal, this voltage is higher than that across the busbars; the exciter field is energized in such a direction as to assist the battery to discharge. The opposite takes place when the generator current is below normal. With proper relations the system works so as to keep the generator load practically constant.

In some cases, the counter-e.m.f. machine has an additional field winding connected across the line and giving a constant excitation. The addition of this winding gives more flexibility to the system and permits of an adjustment for the desired performance of the battery. Further adjustment is made possible by using a rheostat in series or in parallel with the field generated by the exciter, and also by shunting the main series winding by adjustable resistances.

21. Vibrating-Contact Booster Regulator—The success of the Tirrill regulator for controlling voltage in generators led to the idea of applying the same principle to storage-battery regulation. Such a battery regulator with vibrating platinum contacts was recently developed by the Westinghouse Electric & Manufacturing Company.

In common with the systems described in §§ 19 and 20, the booster field is energized either for charge or for discharge by a separate exciter. The exciter, which may be either direct-connected to the booster set or driven by a separate motor, has two equal and opposite field windings, connected in parallel across the main busbars. A third field winding is connected across the armature terminals of the exciter and is its regular shunt winding. A platinum contact actuated by the main generator current short-circuits a resistance in series with either one or the other of the two differential windings and makes the action of one predominant. The shunt winding immediately begins to build up the exciter current, which in turn effects the desired booster regulation. The tendency to over-regulate is checked by an electro-magnet which immediately opens the platinum contact.

22. **Storage Batteries in Alternating-Current Plants**—The question of equalizing load in alternating-current power plants by means of storage batteries is quite important. At present, batteries used in large railway and lighting plants are usually installed in sub-stations; each sub-station is thus regulated separately. A better economy could be obtained by having one large battery in the generator station, even though it would necessitate extra rotary converters or motor-generators between the line and the battery.

On fluctuating loads such batteries have to be controlled by automatic boosters with some relay between the main line and the booster field. The requirement in most cases would be to regulate for constant KW. generator output; the current then varying only with the power-factor.

The problem is in rather an experimental stage, though it would seem that the systems of regulation described in §§ 19 to 21 may be made to operate successfully with alternating currents.

COALITE

FROM "THE CANADIAN ENGINEER"

A new fuel, the use of which is claimed to be more advantageous than coal, is being put on the English market under the name of "Coalite." It has been given much publicity in the columns of British journals.

It is claimed that this fuel will burn under any ordinary conditions without emitting smoky gases, and that it has a higher heat efficiency than the best Welsh steam coal. We have had several inquiries asking for information regarding this new fuel, and for the benefit of those, and many others who will doubtless be interested, the following particulars, taken from the London Standard, as given:

"Coalite is obtained by the distillation of bituminous coal of any size or quality, and the process consists in carbonizing such coals for a period of eight hours in flat, rectangular retorts, ten feet in length, which are placed vertically in a gas-fired furnace, the temperature of which is kept at 800° F., a temperature which just shows a dull red glow when shaded from strong light. These retorts being filled, the swelling of the coal on heating causes a considerable pressure, and results in the formation of a product of good density, while the low temperature prevents the whole of the volatile matter from being expelled, and yields a substance which, although it has a superficial resemblance to coke, differs widely from it in many important points. Each retort takes 15 cwt. of coal at a charge, and yields approximately 11 cwt. of coalite, but this varies with the composition of the coal used, so that, although in most cases the yield is 70% of the coal taken, it may be slightly higher or lower.

"The temperature at which coalite is formed is nothing comparable with the white heat to which ordinary gas retorts are subjected, with the result that the constituents of which illuminating gas is composed remain behind in coalite to an extraordinary extent. The presence of so great a proportion of the gaseous elements of coal also secures the easy ignition of the fuel and its burning with a gentle flame; while the removal of the superfluous volatile elements deprives it absolutely of the power of emitting smoke at any time during its combustion."

A smokeless fuel that will even compare in value to bituminous coal is much to be desired, especially in view of the stringent laws that are being passed in almost every large city for the prevention of smoke. If this new fuel is all that is claimed for it consumers will welcome its speedy advent. Not only will it be possible to use it for manufacturing and domestic purposes, but also under locomotives, the smoke from which is very noxious, particularly where much shunting is done within or near the city limits.

Professor Vivian B. Lewes, of the Royal Naval College, Greenwich, has made some exhaustive tests with "Coalite," and his report on same contains some very interesting figures. According to the report, "Coalite" has a heating value of 13,500 B.T.U. per pound. That of bituminous coal averages 14,800 B.T.U. These figures would lead one to believe that coal is superior to "Coalite," but it is claimed that it is not, owing to the fact that on combustion most of the calorific value of "Coalite" is

converted into heat. Exhaustive tests have shown that about 50% only of the calorific value of coal can be obtained from it. On this basis, taking coal with a heating value of 14,800 B.T.U., only about 7,500 B.T.U. can be utilized, while 13,000 is available in the "Coalite." It has been shown by test that a fire of "Coalite" radiates 1.56 times as much heat as a coal fire of the same size, and from a heat-producing standpoint the "Coalite" fire was much more steady. These figures are more or less convincing, but it is hard to see how coal from which some of the volatile matter has been extracted, can compare in value with the original article.

In the manufacture of "Coalite" there are several by-products, among which is a spirit that can be used as a motor fuel, a fuel that can be sold at a much lower price than either gasoline or petrol. It is estimated that in treating 3,000,000 tons of coal about 7,500,000 gallons of benzol, naphtha, etc., are obtained, and a large percentage of this is suitable for use in motors.

A NEW BLUE-BLACK IRON PAINT*

By F. J. R. CARULLA

In the preparation of iron and steel rods for wire drawing and galvanizing, as also in the preparation of plates for tinning, etc., the iron is kept for a time in a bath of acid to remove the scale. The acid used may be sulphuric acid, when a solution of sulphate of iron ("copperas") is produced; or hydrochloric acid may be employed, when a solution of chloride of iron is obtained.

Methods have been devised to utilize these solutions, but the object of this paper is to describe the one which is the most valuable when chloride liquors have to be dealt with.

The chloride liquors are generally dealt with by adding some base which, combining with the chlorine, will precipitate the iron as an oxide. Lime has been employed; but the calcium chloride produced is a very soluble and deliquescent substance of little use. Certainly the calcium chloride solution might be run away, but it is said to have been successfully employed for watering roads and preventing the dust arising from the passage of motor cars. Potash and soda have also been suggested and employed as bases for the precipitation of the oxide of iron, but the product obtained has obviously a value much below that of the materials employed.

It occurred to Dr. C. F. Wülfing that ammonia might be employed to effect the precipitation in question, seeing that the value of the ammonium chloride is greater than that of the ammonia employed.

The drawback to such a process is that the volatile nature of ammonia necessitates the use of apparatus so closed as to preclude the escape of ammonia, especially as the liquor has to be blown for a long period, in the presence of ammonia, some of which the air would otherwise carry off.

The necessity for this blowing or oxidation arises from the fact that Dr. Wülfing's main object is to obtain a black oxide of iron, which is only produced after long exposure to the air blast. The oxide obtained is a beautiful blue-black color, quite insoluble in water, and when passed into the filter-press leaves a clear solution of ammonium chloride which is evaporated and allowed to crystallize.

The blue-black precipitate is magnetic, showing it to be Fe_3O_4, and is a valuable addition to the list of pigments that can be employed for the protection of structural ironwork.

By similarly treating the chloride liquors with other bases a black color can be obtained, but it is not of the extreme fineness possessed by the substance when ammonia is employed. Whatever method may be employed, absolute chemical purity is unattainable. If the process be attempted with lime, some of this most undesirable impurity remains behind, the color produced, moreover, being of a poor quality. With ammonia, on the other hand, the black oxide is left with a trace of a double salt, which Dr. Wülfing regards as NH_4Cl, $FeCl_2$. This acts beneficially on the paint, although ammonium chloride by itself would not do so. Structures that have been painted with this blue-black oxide of iron (boiled linseed oil being used in the prepration of the paint) have kept fresh though exposed to the weather for nearly two years, still showing a varnish-like surface.

*A paper read at the Vienna meeting of the Iron and Steel Institute.

chanical Equivalent of Light.—Experi-s recently carried out by Dr. C. V. Drys-and Mr. A. C. Jolley, and reported to the l Society, lead to the conclusion that an source of white light should yield about ndle-power per watt, and a monochro- yellow-green source about 17 candle-r per watt.

ong Cast Iron.—According to a writer in allurgie," for high tensile strength and ess a casting should contain from 20 to of its total carbon as combined carbon, being effected by the presence of from 1 to of silicon and 0.06% to 0.15% of sulphur, ding to thickness, with about 0.5% of ganese and from 0.2 to 0.5% of phos-us. For high bending strength com- with low tensile strength the silicon ld range from 1.4 to 2%, with Mn, P and low as possible.

ensity of Daylight Illumination.—Experi-s made in Munich last August, by Herr auius, gave the following results: For ontal surfaces at ground level, direct il-nation: 8 A. M. (slight mist, but no s), 2,380 candle-feet; 12:30 P. M. ht sunlight), 6,220 candle-feet; 6:30 P. 08 candle-feet. Other experiments made e shade at 11 A. M. gave values of from to 290 candle-feet, for varying conditions y.

nding New Concrete to Old Work.—The ome patented process for accomplishing onsists of thoroughly washing the surface e old concrete with water, and then flood-he surface thus cleaned with a prepara- which removes the greasy film which on concrete surfaces hardened under ex-e to air. This mixture is swept slowly the surface until its strength is spent. this the surface is washed with water, a cream of cement and water is applied. is then brushed with brooms, and a paste ick cream of cement and water is spread y over the surface to a depth of from 1/16 to 1/8 in. Before this last coat has be-gun to set perceptibly, the new concrete work is put on in the regular way.

Heavier Loads on Rails.—According to Mr. H. V. Wille, of the Baldwin Locomotive Works, the average total weight on the driving wheels of locomotives has increased from about 69,000 lbs. in 1885 to over 180,000 lbs. at the present time, and has reached a maximum of 316,-000 lbs. The average axle load has increased at the same time from 22,000 lbs. to 48,000 lbs. The percentages of increase for the various classes of engines all converge to a common value, showing that the increase is being cared for by distributing it over a greater number of drivers.

Snow-Load on Roofs is the subject of some recent investigations by Mr. S. de Perrot, of Neuenburg, Switzerland. Where a heavy fall of snow is followed by thawing and freezing successively and then more snow, and thus in repeated cycles, a coherent laminar mass of snow and ice is formed on roofs, which is of remarkable density. Several such "snow" accumulations proved to have a weight of 36 to 38 lbs. per cubic foot. In these cases the thickness of the accumulated snow on the roof was 24 ins. to 32 ins., thus producing a load of 70 lbs. to 100 lbs. per square foot. This is three or four times as much as is commonly assumed in calculations.—"The Engineer" (London).

High-Pressure Steam.—Important researches upon the use of high-pressure steam—up to 1,500 lbs. per sq. in.—in steam turbines have been conducted by Dr. de Laval. He finds that the present tables giving the properties above 350 lbs. pressure—432° F.—are unreliable, the values having been extrapolated. One remarkable deduction is that at about 640° steam seems to have a maximum efficiency. This is apparently paradoxical, for theoretically the thermodynamic efficiency is greater the higher the temperature. The probable explanation is the rapid decrease in the latent

heat as the critical temperature—689°, according to Cailletet; 698°, according to Regnault, is approached. — "The Eingineer" (London).

Melting and Boiling Points.—The following table, taken from "The Mining World," is based on the authority of Dr. J. A. Harker of the National Physical laboratory of England, and is published as an important reference table for scientific and technical workers:

Boiling points.	Centigrade.	Fahrenheit.
Liquid hydrogen	—253	—423
Liquid oxygen	—182	—295
Mercury (freezing)	— 39	— 38
Water at 760 mm. pressure	100	212
Sulphur at 760 mm. pressure	445	833
Melting points.		
Tin	232	449
Lead	427	620
Zinc	419	786
Antimony	632	1169
Aluminum	657	1214
Common salt	800	1472
Silver (in air)	955	1751
Silver (in reducing atmosphere)	962	1763
Gold	1064	1947
Copper (in air)	1062	1943
Copper (in reducing atmosphere)	1084	1983
Nickel	1427	2600
Pure iron	1503	2737
Platinum	1710	3110

Decomposition of Platinum.—Dr. Theodore Grosse the German chemist, has just announced through the "Chemiker Zeitung" that by a combination of physical and chemical forces he has brought about the decomposition of platinum, which has hitherto been looked upon as a single element. "This discovery, if substantiated," says Dr. W. A. Hamor, research chemist of the College of New York, "will rank with Sir William Ramsay's recent degradation of copper into lithium, as of the utmost importance to chemists, though probably of no great commercial significance."

Dr. Grosse says that when the decomposition of platinum was effected he obtained an unknown chemical element consisting of black crystals in no way responding to the usual tests of platinum.

His method was as follows: Molten potassium carbonate was subjected to great heat in a platinum vessel. This was for many hours subjected to an alternating electric current between platinum electrodes, with the occasional addition of nitre. By this treatment the electrodes were attacked and became coated with needle shaped crystals of the color of charcoal. At the same time the platinum vessel and electrodes lost weight, and on extracting the melt a brown powder, free from potash and carbon, was obtained.

The crystals and powder yielded solutions which were precipitated by sulphuretted hydrogen, but no platinum was present. Dr. Grosse confirmed this by experimenting with melted potash and a mixture of the two strongest acids, sulphuric and nitric, which respectively replaced the carbonite of potash. The crystals and brown powder thus revealed the presence of an unknown substance, and consequently a new element.—"New York Times."

The Efficiency of Crucible Furnaces is always very low. In round numbers about 100 lbs. of coke will be required to melt 100 lbs. of brass. The amount of heat theoretically required can be calculated. Assume that it is copper which is to be melted for convenience (melting point 1,085° C.). The specific heat of copper is, according to Frazer and Richards, $0.0939 + 0.0000177St$, so that the heat required to raise 1 lb. of copper from 0° to its melting point, 1,085° C., will be $1{,}085 \times [0.0939 + (0.0000177S \times 1.085)] = 122$ units approx. Taking the latent heat of fusion to be 45, the heat required to raise 1 lb. of copper to its melting point and to melt it would be about 167 units, or for 100 lbs., 16,700. As coke may be taken as having a calorific power of, say, 6,400, 2.6 lbs. of coke would be sufficient to melt 100 lbs. of copper. Taking the amount given above, the efficiency of the furnace will be 2.6%.

It is easy to see the sources of the loss: (1) The coke is not completely burnt to carbon-dioxide, but a considerable portion escapes as carbon-monoxide; (2) the products of combustion must leave the furnace at a high temperature in order to produce a draft. These sources of loss cannot be avoided, but owing to faulty furnace construction, the actual loss is often much higher than it need be.—"The Mechanical Engineer."

BOOK DEPARTMENT

THE PHYSICAL SIDE OF BOOKS

To book readers, as well as to those who work among books, it is worth while to become familiar with their physical features—their binding, paper, type, illustrations and other like parts. To learn about these things pays, because knowledge of them adds to the sum of one's interest and because much of the knowledge one may acquire about them is of actual use in daily work, helping to judge of book values, to order bindings with discrimination and to handle books with good judgment; again, because in learning about the physical features of a book one not only gets useful information on several trades which are parts of the broader trade of bookmaking, but acquires also that habit of criticising, estimating, or appreciating which leads to the development of good taste and to an interest in objects of art.

In an article in "The Library Journal," Mr. John C. Dana, Librarian of the Newark (N. J.) Public Library, treats this subject from the viewpoint of the librarian. He selects 27 things in books as especially worthy of study and suggests that librarians and their assistants make a collection of specimens, carefully mounted and arranged for detailed study. To the average reader of books, however, this detailed study would answer no useful purpose, but still, some knowledge of the characteristics of the materials that enter into the manufacture of books would add somewhat to the interest in them.

Few publishers print their own books. The making of books is a special part of the great field of printing. Book makers of the better sort have in their employ expert designers who lay out books for compositors and pressmen, much as an architect lays out a house for masons and carpenters. The designer examines the manuscript and discusses it with the publisher; then, taking into consideration its subject, length, character, style, probable market, appropriate price, possible sales and number of copies to be issued, specifies its paper, type, size of the pages of type and paper, head lines, title page, chapter headings, ornaments, binding, and all the other details that go into its construction. As an expert book designer he is familiar with every feature of bookmaking, and every book he lays out speaks through all its parts of his skill and knowledge, or of his lack thereof.*

The physical features of books include: Book papers, inks, and bindings of paper, cloth and leather.

Most of the book papers of today are made of rags and wood fibres; among other materials used are the waste product of sugar cane, corn stalks, hemp, wild clover and several other plants which have a good fibre. Of rags, only linen and cotton are used. Linen rags make a strong paper which is mostly used in manufacturing fine writing papers, ledgers and covers for books where strength is necessary. The stock usually used for books is made from spruce or fir pulp. This is reduced or disintegrated either by sulphurous acid or by caustic soda, or by grinding; this last is used for stock in very low grades of paper, such as newspaper and wrapping paper but rarely for book paper. Many persons think that this ground wood, which is merely spruce ground very fine into pulp, is used for book papers; but if it were, the paper would not last long and would almost immediately discolor on exposure to light and air. There is a theory that no paper made from wood fibre is lasting, and that high grades of paper for fine books should be made only of rags, but this is erroneous, for wood and rag stock nowadays are treated and prepared in the same way, and only practically pure cellulose matter goes into the paper. It

*In this connection, we refer the reader to the article, "The Building of a Book" in Technical Literature for May, being a review of the book of the same title, edited by Frederick H. Hitchcock, published and copyrighted, 1906, by the Grafton Press, from which, also, much of the material in this article is reproduced, by permission.

would be a different matter, however, if crude ground wood were used for fine papers, for in this stock the cellulose matter is not separated.

Besides the regular paper stock used in making the book, there is a lining paper, used to line the insides of the covers. In most books, this is simply a sheet of paper on which the book is printed; the first and last leaves being pasted down to the covers, front and back. But many books, and especially the carefully bound ones, have lining papers selected with reference to their size and character, to the color of the leather on their backs and of the paper or cloth on their sides.

Printing ink consists of a pigment, black, white or colored, ground into a suitable varnish. The pigment is that constituent which makes the impression visible, while the varnish is the vehicle which carries the pigment during the operation of grinding and during its distribution on the press to the type, from the type to the paper and ultimately binds it to the paper. The machinery used to accomplish this grinding and mixing consists, first, of mixers, in which the ingredients are thoroughly incorporated with each other. This being done, the resulting mixture or "pulp," is ground up in mills formed of cylinders set in close contact. Between these rolls the pulp is passed again and again, the number of times being dependent upon the consistency of the ink and the nature of the pigments; until it is ground to the utmost fineness. The result is printing ink as it is known to the printer, varying in consistency, strength, intensity, permanency, brilliancy, drying, and other working qualities, according to the nature of the various varnishes, dryers, and pigments from which it is made.

Bindings are of paper, cloth or leather. The paper covers are used for pamphlets and cheap editions and are made in an endless variety of quality, weight and color. The great majority of books of all kinds are now bound in cloth, but until the beginning of the last century cloth was almost unknown as a material for covering a book. Books were then very costly, being printed by hand on paper made by hand, and were considered worthy of the most lasting bindings. As the life of books depends on the strength and wearing quality of the covers, such materials as wood, vellum and leather, often reinforced with metal, were generally used. During the past century, improvements in methods and machinery so reduced the cost of printed sheets that a demand arose for a correspondingly cheaper material for bindings. The want was satisfactorily met by the use of cloth, and from the day that it was first used it has become more and more a factor in book manufacturing. Book cloths, from their appearance and manufacture, fall into two divisions, the first being called "solid colors" in which the threads of the cloth are not easily distinguishable. The second division consists of the "linens" and "buckrams" in which each thread, with the imperfections and peculiarities of the weaving, are plainly seen and form a large part of their picturesque effect.

The first of the "solid colors" to be used was black cloth, but they are now made in many colors, though chiefly in simple pronounced shades, such as browns, blues, greens, and reds. These cloths are dyed and sized with a stiffening preparation. They are used in various patterns, which are embossed on the surface during the process of manufacture.

Of the second division of cloths, in which the appearance of the threads becomes a part of the effect, there are first the "linen" cloths. The chief characteristics of these is that the coloring used fills the interstices, but allows all the threads to be clearly seen. The irregularities of the weaving, therefore, stand out plainly, and produce to a certain extent the appearance of woven linen fabrics. The linen cloths are specially used for school and other books which are constantly handled, as their construction shows the wear less than do the solid colors.

A "linen" cloth, observed through a microscope which magnifies the threads to a coarseness of about forty to an inch, gives the exact appearance of a "buckram," which is a heavy, strong cloth well adapted to large books and which furnishes the most durable binding of all the book cloths.

Buckrams are sometimes embossed to imitate in part the appearance of an irregularly woven fabric called "crash." This is a special cloth which might be classed with the buckrams, and when suitably used is a very artistic material.

Basket cloth is still another material which could be included with the buckrams. In this grade of cloth the threads are woven in squares resembling a basket mesh, from which fact the name is derived.

One cannot stand before the windows of any large book store, especially at holiday

time, without being impressed with the possibilities offered by the many colors and patterns of cloths and the varied hues of inks and embossings. The designer of book covers has surely a wider field to-day than when he confined his attention entirely to making designs for single leather-bound folios.

For leather bindings there is hardly any part of the world that has not been drawn upon for suitable skins. These are generally goat, seal, pigskin, cowhide, calf, and sheep, and they vary in quality according to the country they come from and the manner in which they are cared for, the stall-fed animals, or those that are protected from storm and have regular food, producing the best skins. Leather manufacturers are able, by using splitting machines, to split skins so that both parts of a skin can be used. Were this not the case, it would be impossible for the binder to supply the needs of his customers, as the output does not keep pace with the demand. In fact binders are constantly looking for substitutes, but, after all, there is nothing so good as leather.

AMERICAN AND BRITISH PUBLISHERS

THEIR "TRADE MARKS" AND SOME INTERESTING DATA

In the November "Technical Literature," some data regarding a number of American publishers were given; in this issue we conclude the list with the addition of the principal British houses.

SIDNEY APPLETON, London. Founded 1901. Publish educational, medical and scientific books and act as European agents for D. Appleton & Co., New York.

ADAM AND CHARLES BLACK, London. founded 1807 by Adam Black; present head of house, Adam Black, grandson of founder. Publish general and educational literature.

BLACKIE & SON, Ltd., London, Dublin and Bombay. Founded 1809 by John Blackie, Sr.; Chairman of present company, J. Alexander Blackie. Publish educational, technical and general literature.

One of the oldest British publishing houses and existed many years before 1809 under the name of A. & J. Brownlie, into whose employment John Blackie entered as a youth. He finally succeeded to the business and in time took his sons into partnership, which was later incorporated into a private limited company, all the directors being direct descendants from the original John Blackie, Sr.

JAMES BROWN & SON, Glasgow and London. Founded 1852 by James Brown; present head of firm, R. Irving Brown. Publishers of the "Nautical Magazine," (established 1832), and nautical books and almanacs; about 60 titles.

Device a registered trade-mark, signifying navigation.

The BOBBS-MERRILL CO., Indianapolis and New York. Founded in 1838 by Samuel Merrill. Present head of house, W. C. Bobbs. Publish general literature, principally fiction and poetry.

CAMBRIDGE UNIVERSITY PRESS, London and Glasgow, with agencies in the United States, Canada and India. Founded in 1520 by the University of Cambridge, now controlled by the Syndics of the Press—a body chosen from the Senate of the University.

The publications of the Cambridge Press number very many thousands and include a large proportion of the most important works published in England on higher mathematics,

physics, chemistry and general science, and also an important series of works in English literature, general literature and history, theology and philosophy.

The device used on the covers of all or nearly all books is a representation of the arms of the University of Cambridge.

WILLIAM AND ROBERT CHAMBERS, London and Edinburgh. Founded 1832 by Wm. and Robt. Chambers; present head of the house, Charles E. S. Chambers, grandson of Robt. Chambers. Publishers of "Chambers' Journal," Chambers' Encylopedia and school books.

CHAPMAN & HALL, Ltd., London. Founded in 1830 by Messrs. Chapman and Hall as a partnership.

Publish technical and general literature and act as British agents for John Wiley & Sons, of New York.

CHATTO AND WINDUS, London and New York. Founded 1853 by John Camden Hatten, who died in 1873 and was succeeded by the present firm, of which Mr. Andrew Chatto is head.

Publish art, fiction and general literature. Device consists of head of Minerva from a gold stater of Alexander the Great, struck about B. C. 330, probably at Corinth.

W. C. and F. P. CHURCH, New York and Washington. Founded in 1863 by the present head of the firm, W. C. Church. Military and naval works; 10 titles.

J. AND A. CHURCHILL, London. Founded 1825 by John Churchill; firm now consisting of Augustus, A. William and J. Theodore Churchill. Publish medical and scientific books.

MYRON C. CLARK PUBLISHING CO., Chicago and New York. Founded 1904 by Myron C. Clark.

Publishers of "Engineering-Contracting," "Roadmaster and Foreman," "Chemical Engineer" and technical books; about 20 titles.

P. F. COLLIER & SON, New York, with branches in large cities of United States and Canada.

Founded in 1875 by Peter F. Collier, still head of firm. Publish periodical and miscellaneous literature; about 300 titles. Use a device of a purely symbolic character.

CONCRETE PUBLISHING COMPANY, Detroit. Founded 1904 by D. N. Harper; present head of company, E. R. Kranich.

Publishers of "Concrete" and books relating to cement and concrete. Use as a publisher's mark the name of the publication.

CROSBY LOCKWOOD & SON, London. Founded 1860. Publish technical, scientific and educational books; about 1,000 titles.

Device represents a hand holding a torch with the motto "Capio Lumen"—"I hold a torch"—the initials of which are the same as those of the firm name.

DAWBARN AND WARD, Ltd., London and New York. Founded in 1894 by John C. Dawbarn and H. S. Ward; still principal directors. Publish books on photography, handicrafts, horticulture, agriculture, etc.; about 150 titles. Use as a special mark a diagonal band of dark blue on light gray covers.

G. W. DILLINGHAM COMPANY, New York. Founded 1857 by Geo. W. Carleton; present head of house, John H. Cook.

Publishers of fiction and miscellaneous books; about 1,100 titles.

Since its foundation the firm has passed through various changes in name—Rudd and Carleton and G. W. Carleton & Co., before the formation of the present company.

The device used is merely the Arabic sign for "Books," but it also serves as a monogram of the letters G. W. C.

THE GRESHAM PUBLISHING CO., London, Dublin and Bombay. Founded 1898. Publishers of technical and standard works of reference; about 50 titles.

THE GORHAM PRESS, Boston. Founded 1901 by present head of house, Richard G. Badger. Publish special magazines and general books; about 250 titles.

Device represents the tree of knowledge and apple of learning; an outgrowth of the printing press.

NORMAN W. HENLEY & COMPANY, New York. Founded 1890 by Norman W. Henley.

Technical, scientific and practical books; about 100 titles.

Device, Lamp of Knowledge.

Duckworth

Longman

Bell

Longman

Werner Laurie

Hurst & Blackett

Macmillan

Constable

Smith, Elder

Alston Rivers

Greening

Black

Blackwood

Blackie

Sonnenschein

Heinemann

Macmillan

John Lane

Chatto

Murray

Bell

Murray

Cassell

Chapman & Hall

Dent

Elliot Stock

Fisher Unwin

Oxford University Press

Routledge

Kegan Paul

TRADE MARKS OF British Publishers

Arrowsmith

George Allen

(The illustrations reproduced herewith appeared in the "Book Monthly," December, 1906, and were supplied to Technical Literature by Messrs. W. & R. Chambers, Edinburgh.)

INDUSTRIAL PUBLICATION CO., New York (Charles G. Pelker). Founded 1870 by John Phin.

Building trades, principally carpentry; 110 titles.

Device is a pictorial representation of the old quotations "Knowledge is Power" and "The Pen is Mightier Than the Sword." The pen, resting on the printing press as a fulcrum, is the lever that raises the world, while the sword breaks in the attempt.

THE KOHLER PUBLISHING CO., Philadelphia, Pa. Founded 1848 by Ignatius Kohler; present head of the house, Rudolph K. Wolf.

Publishers of religious, classical literature and dictionaries; about 150 titles.

LEA BROTHERS & CO., Philadelphia and New York. Founded 1785 by Mathew Carey. Publishers of Medical and Historical books.

The device used by this house is a shield with the motto "Quae Prosunt Omnibus"—"Those things which benefit all"—about the edge. On the face of the shield is the winged staff of Mercury, the God of arts and sciences, with the two snakes entwined about it. The wings of the staff typify Mercury as the messenger of the gods and the diffuser of knowledge. As a whole the imprint denotes the universal benefits flowing from the dissemination of medical knowledge.

A. C. McCLURG & CO. (Incorporated), Chicago and New York. William F. Zimmerman, President. Established 1844 as W. W. Barlow & Co. General literature; about 1,000 titles.

Device: A scroll work embodying the acorn, which was selected by the late president of the house, General A. C. McClurg, for the reason that it was the badge of the 14th Army Corps, to which he was attached during the Civil War.

McGRAW PUBLISHING CO., New York. An amalagamation of several companies doing business since 1874. James H. McGraw, president.

Publish "Engineering Record," "Electrical World," "Street Railway Journal" and technical and engineering books; about 250 titles.

METHUEN & COMPANY, London. Founded 1889 by Algernon M. S. Methuen. Publish fiction and general literature; about 3,000 titles.

MOODY CORPORATION, New York and Chicago. Founded 1900 by John Moody, now president of company.

Publishers of financial books; 25 titles.

Device used is a monogram arrangement of the initials of the company.

MUNN & CO., New York and Washington, D. C. Founded in 1845 by Orson D. Munn and Alfred E. Beach. Present head of company, Charles A. Munn, president.

Publishers of "Scientific American" and scientific books; 15 titles.

JOHN MURRAY, London. Founded 1768 by John Murray; now controlled by John Murray, the fourth in direct succession.

Publishes biographical and general literature.

J. S. OGILVIE PUBLISHING COMPANY, New York. Founded in 1882 by J. S. Ogilvie. Publishers of fiction and technical books; about 1,000 titles.

THE OLD GREEK PRESS, Chicago. Founded 1903 by Sherwin Cody.

Publish books on literature and commercial English; 20 titles.

Device is adopted from Flaxman's head of Homer.

OXFORD UNIVERSITY PRESS, London, Edinburgh, Glasgow, New York and Toronto. Founded in 1713 by Lord Clarendon; now managed by Henry Froude, as delegate of the Clarendon Press, Oxford.

Have published many thousands of books on religious, educational, medical, philosophical and juvenile subjects.

PENN PUBLISHING CO., Philadelphia. Founded 1889 by Chas. C. Shoemaker. Miscellaneous publications; about 500 titles. Device used is a monogram of letters P. P. Co.

SCOTT, GREENWOOD & SON, London, with agencies in New York, Toronto, Bombay, and Tokio.

Founded 1875 by Thomas Greenwood and W. H. Smith; present head of firm, Thomas Greenwood. Publish technical books and trade journals; about 250 titles.

SAMPSON LOW, MARSTON & CO., Ltd., London. Founded towards the close of 18th century by Sampson Low, who died in 1800. Managing Directors of present company, Walter Tyrrell and Fred. J. Rymer.

Publish works on travel, biography, history, fiction, fine arts and technical subjects; to date about 6,300 titles. Device represents the tree of knowledge springing from a book, associated with the sun, symbolizing light and the dissemination of knowledge. The ship also suggests the spreading of knowledge, and the castle signifies the strength that knowledge gives.

Among the authors whose books have been published by Sampson Low, Marston & Co., are Stanley, the explorer, Harriet Beecher Stowe, Lord Lytton, Charles Reade, Jules Verne, William Black, Wilkie Collins, Oliver Wendell Holmes, Louisa M. Alcott, Victor Hugo, and others of equal prominence.

CHARLES SCRIBNER'S SONS, New York. Founded in 1846 by Charles Scribner; present head of house, Charles Scribner, son of founder.

Publishers of fiction, religious and educational literature.

Device consists of a lamp surrounded by rays of light, and words "Scribner's Magazine," the whole enclosed in a wreath.

JULIUS SPRINGER, Berlin, Germany. Founded in 1842 by Julius Springer; present members of firm, Fritz, Julius and Ferdinand Springer. Publish works on medicine, physics, chemistry, biology and engineering and technical subjects; about 3,500 titles.

Device consists of a shield with J. S. in monogram, and motto "Alle Zeit Wach"—, and date 1842; all surmounted by a Knight (chess-figure)—in German "Der Springer."

SIBLEY & COMPANY, Boston and Chicago. (Charles A. Sibley) founded 1898. Publications: School text-books, about 100.

Device represents an open book showing the monogram "S. & Co." and two Greek words meaning "Best only."

E. & F. N. SPON, Ltd., London. Founded 1830 by Edward Spon. Present head of company, F. N. Spon. Publish engineering and technical books; about 1,000 titles.

TAYLOR PUBLISHING CO., Chicago and New York. Founded 1881 as The Engineer Publishing Co., by W. H. Taylor, president.

Publishers of "The Engineer" and technical books; 10 titles.

UNIVERSITY OF CHICAGO PRESS, Chicago and New York. Founded in 1902 by Newman Miller.

Publish scientific, educational and religious books and pamphlets; 400 titles.

Device, stamped on the backs of the books, represents the Chicago River with its two branches. This same idea is embodied in the trade marks of several Chicago houses.

THOMAS FISHER UNWIN, London and Leipsic. Commenced business in 1882. Publishes general literature; over 3,000 titles; also acts as agent for the sale of the government ordnance survey maps.

Uses several devices, one of which is shown on page 575.

WARD, LOCK & CO., Ltd., London, Melbourne and Toronto. Founded in 1858 by George Lock and Ebenezer Ward; present head of company, R. Douglas Lock. Publish popular fiction and miscellaneous books. Device consists of letter W in monogram surrounded by the name of company.

WHITTAKER & CO., London and New York. Founded 1783. Publish technical and general literature.

H. W. WILSON CO., Minneapolis and New York. Founded in 1889 by H. W. Wilson.

Publishers of bibliographic lists and miscellaneous books; about 75 titles.

THE PUBLIC LIBRARY OF THE DISTRICT OF COLUMBIA

OPENING OF NEW ROOM FOR ENGINEERS, MECHANICS AND BUSINESS MEN

On November 5 the Public Library of the District of Columbia formally opened a special department of useful arts and sciences, the resources of which were described by Mr. George F. Bowerman, the librarian, in an address before the Washington Society of Engineers. The opening of this department is the result of an effort on the part of the librarian to overcome the popular idea that a public library is a depository of the latest fiction, juvenile literature, history, etc., and to make it of practical use to the business man who uses books, not as playthings, but as tools.

Space has been provided for nearly 7,000 volumes, and everything in the room—books, magazines and trade catalogues—is on open shelves, every volume being available for readers without consulting the card catalogue. The classes of books indexed include pure science, mathematics, astronomy, physics, chemistry, geology, patents and inventions; the various departments of engineering, agriculture and forestry, railroads, telegraphs, telephones and all the arts of communication; advertising, and all the growing literature on business specialties, printing and bookbinding; the various mechanic trades, and certain fine arts related to technical work.

The building up of this department has been a work of only three years—a short time for the development of such an important part of the equipment of a large library, but possessing the advantages that most of the material in it is new. The library does not include on its staff any one having expert knowledge of technical books, and has relied entirely on lists bearing evidence of preparation by qualified experts. The first extensive purchase consisted of all the books on the useful arts included in the American Library Association Catalogue of 1904; later there appeared the list of technical books for libraries, prepared by a committee of the Society for the Promotion of Engineering Education, all of which were purchased, as well as the books in the revised edition of this catalogue published a year ago. During the past two years or more the book reviews in the "Engineering News," and later in "Technical Literature," have been carefully read, and practically all the books recommended have been purchased. The library also makes use of many brief lists prepared by experts, such as a list of electrical engineering literature by Prof. H. H. Norris, of Cornell University, and the list of waterworks literature by M. N. Baker.

One of the most important sections of the department is that which includes periodicals, both the current files and the bound sets. There are 105 current periodicals regularly on file, 55 of which are devoted to the more restricted fields of engineering; 50 are on general science, useful arts and commercial affairs.

The volume of this periodical literature is so great that current periodical indexes are indispensable. The library has available all published indexes, and for current literature makes use of the monthly index in "Technical Literature."

A highly important source of material supplementary to text-books and periodicals is found in manufacturers' trade catalogues. Some of these are the work of highly paid engineers, who are employed by manufacturers to discover new methods, processes and applications, the results of which are published in handsome, expensive and interesting catalogues. A very complete collection of these catalogues has been made by the library, covering nearly every class of engineering, industrial and commercial work. This material is carefully classified; it is kept in pamphlet boxes, and is indexed by firms and subjects.

That the opening of this technological department will be of great service to a large class of people, and prove the value of the library to the engineer and the business man, has already been shown by the large demand for books.

BOOK REVIEWS AND NOTICES

EXPERIMENTAL AND THEORETICAL APPLICATIONS OF THERMODYNAMICS TO CHEMISTRY.—By Dr. Walter Nernst, Professor and Director of the Institute of Physical Chemistry in the University of Berlin. New York: Charles Scribner's Sons. Cloth; 5¼ × 8 ins.; pp. x + 123; $1.25 net.

Thermodynamics may be defined as the science of heat considered as a form of energy. As such its principal practical usefulness has been in the study of the physical transformations of gases and vapors under the influence of changes of temperature and pressure. Two so-called laws of thermodynamics have been recognized.

The First Law of Thermodynamics can be defined thus: "The sum of the different kinds of energy in an isolated system is always the same, no matter what forms the energy may assume." An isolated system is one which neither receives nor gives up energy to its environment. It follows from this definition that the quantity of heat in a body, expressed in calories for example, can also be measured by mechanical units, such as foot-pounds, or ergs. It has been found by experiment that the quantity of heat required to raise the temperature of one kilogram of water from 0° C. to 1° C., called one calorie, is equivalent to 41,-914,000 ergs. Stated differently, the quantity of heat necessary to raise one pound of water from 60° F. to 61° F., called one British Thermal Unit (B.T.U.) is equivalent to 778 foot-pounds of work.

Practically all chemical reactions either evolve heat or absorb heat during their progress. Therefore the energy of a chemical reaction can be measured in terms that fall within the scope of this First Law. In other words, thermochemistry, which concerns itself with the measurement of the quantity of heat produced or absorbed in chemical changes, is simply one of the applications of this law.

The Second Law of Thermodynamics can be expressed in various ways. The fundamental idea involved is that heat cannot pass of itself from a colder to a hotter body. It has also been defined thus: The total energy in a system is proportional to the absolute temperature. Clausius defines it by the statement that in a perfect, a reversible cycle, the sum of the equivalences of all the energy transformations is zero. Mechanically, the last definition of the law is explained and illustrated by Carnot's Cycle, to describe which would unduly lengthen this review.

In chemistry the Second Law of Thermodynamics has been applied to the study of certain physico-chemical processes, such as volatilization, melting, transformation of allotropic forms into each other, and the latent heat of reactions.

In the book before us Nernst, in a course of Silliman Memorial Lectures at Yale University, has briefly elaborated these applications to chemistry of this Second Law, principally by means of a mathematical equation called by him "the equation of the reaction Isochore," an equation first proposed by Van 't Hoff. This equation is founded upon Clausius' definition. By means of the equation Nernst and his pupils have attempted to "penetrate more deeply into the relations between chemical energy and heat." The mathematical and experimental methods employed for this purpose, and the results obtained are discussed in this book, which is really a summary of many original articles.

The first lecture is devoted to an introduction relating to the general application of Thermodynamics to Chemistry. In this lecture the mathematical work is greatly abbreviated, making it sometimes rather difficult to follow the thread of his ideas.

In the second lecture, Nernst goes fully into the mathematical derivation of the equation of the reaction Isochore. Here the mathematical reasoning is quite fully and clearly worked out.

The third and fourth lectures describe some experimental researches on chemical equilibria at high temperatures, with a view to the application of the Isochore equation.

The fifth, sixth and seventh lectures relate to the integration of the aforesaid equation, and to the determination and evolution of the integration constant. The result obtained is designated the "Chemical Constant"; it is dependent upon the substances involved in the reaction. These three lectures are chiefly mathematical, but various experimental data are drawn upon to furnish material thereto.

Lectures VIII. and IX. apply the foregoing results to the calculation of Chemical Equili-

bria in homogeneous gaseous systems. It is shown that the calculated figures agree very well with the observed results in twelve of the fourteen cases considered.

The last lecture takes up the calculation of chemical equilibria in heterogeneous systems and of electromotive forces.

Nernst has here produced a thoroughly interesting and readable book on a very abstruse and difficult subject. As a résumé of the question of chemical equilibria at high temperatures it will have a distinct value.

The type is large and clear, the paper and binding are good.

A COURSE IN MATHEMATICS.—For Students of Engineering and Applied Science. By Frederick S. Woods and Frederick H. Bailey, Professors of Mathematics in the Massachusetts Institute of Technology. Volume I: Algebraic Equations; Functions of One Variable; Analytic Geometry; Differential Calculus. Boston and New York: Ginn & Co. Cloth; 5½ x 7¼ ins.; pp. xii. + 385; 219 figures. $2.25; postpaid, $2.40.

This book is the first volume of a course in mathematics in which the authors, who are instructors of standing and experience, present in a consecutive and co-ordinated manner the matter that is usually set forth in distinct courses under the classifications of algebra, analytic geometry, differential equations and differential and integral calculus. The course includes the work usually required of students in the first two years in an engineering school, the present volume covering that of the first year. In the arrangement of subject-matter, however, the authors have disregarded precedents and have struck out on a new line, ignoring the traditional divisions before mentioned, introducing principles as needed, and developing the subjects together. In this way it is believed that the student will obtain a better grasp of mathematics as a whole, and of the interdependence of its various parts, and become accustomed to use, in later work, the methods best adapted to the problems attacked. The principles of analytic geometry and calculus are in this way brought before the student much earlier than is usual, thus conducing to greater familiarity with their methods and greater freedom and skill in their application.

Chapter I. is devoted to the subject of elimination, and includes the use of determinants. In the second chapter graphical representation is taken up, and the use of a system of co-ordinates and the definition and plotting of a *function* are set forth. The study of the algebraic polynomial is then begun, the treatment comprising the analytics of the straight line, the more important theorems of the theory of equations, and the elements of differentiation. Chapters VI.-XII. are devoted to the study of the algebraic function in general. The knowledge already obtained is here much amplified by further applications of the principles involved. Elementary applications of integration are also introduced. The study of conics forms part of this work, but other curves are also given, and the fact is emphasized that the subject is not exclusively devoted to conic sections. Chapter XIII. treats of the elementary transcendental functions, their graphs and differentials; also the solution of transcendental equations; a knowledge of elementary trigonometry is assumed on the part of the student. Chapters XIV.-XVI. are on the parametric representation of curves, polar co-ordinates and curvature.

This volume embodies the matter usually given in a first course in differential calculus, with the exception of differentials, series, indeterminate forms, partial differentiation, envelopes and some advanced applications to curves. These subjects, together with three-dimensional analytics and integration, are left for appropriate consideration in the succeeding volume. In the development of the course abstract discussions have been avoided, and frequent applications and illustrations given—all within the range of a first-year student's knowledge of physical science. The work has been written in the atmosphere of a great technical school by men who thoroughly appreciate the importance of mathematics as a tool to engineers, and the rationality of its plan should commend it to the extended consideration of technical educators.

HANDBOOK OF AMERICAN GAS-ENGINEERING PRACTICE.—By M. Nisbet-Latta, M. Am. Gas Inst., M. Am. Soc. M. E. New York: D. Van Nostrand Co. Cloth; 5¾ x 8¼ ins.; pp. xi. + 466; 98 illustrations in the text and many tables. $4.50, net.

In this work the author has endeavored to present a practical treatment of modern gas engineering in such a form that it may be conveniently employed for reference purposes. The needs of gasmakers, foremen and manual operators, as well as of students, have been considered in its preparation. The text is divided into three parts. Part I. is devoted to water-gas manufacture, chapters being given on the following topics: The carburetter; the

superheater; wash-box and tar; scrubbers; condensers; purifiers; exhausters; station meters; details of works operation; holders. The author states in his preface that descriptions of other methods of manufacture are reserved for subsequent editions. Part II. takes up the subject of distribution, chapters being included on mains, services, consumers' meters, pressure, house piping and appliances. Cost data are given on installing mains, pipe laying, trenching and subaqueous mains. Part III., of about 200 pages, is a compilation of general technical data on the properties of gases, calorific values, calorimetry, properties of steam, chimneys, flue areas, steam-boiler practice, etc. Many mathematical tables and conversion factors are also given. The concluding 90 pages are largely given up to details regarding pipe, fittings, pipe laying.

PRODUCER GAS.—By J. Emerson Dowson, M. Inst. C. E., M. Inst. M. E., and A. T. Larter, B. Sc. (London), F. C. S., Associate of the City and Guilds of London Institute. Second Edition. London, New York and Bombay: Longmans, Green & Co. Cloth; 5¾ × 9 ins.; pp. 304; 74 illustrations in the text. 10s. 6d. American price, $3.00.

The first edition of this work, published less than a year ago, was very favorably reviewed in the engineering press. In the present edition a few typographical errors have been corrected, and considerable matter added to the chapters on suction plants. The contents are as follows: Theory of producer gas (3 chapters); furnace work; heating work; suction plants (2 chapters); gas from bituminous coal for engine work; stand-by losses; comparison of gas and steam power; fuel; analysis of fuel and producer gas; calorific power of solid and gaseous fuels; practical notes. Appendixes are included which give the results of tests on 30- to 40-HP. suction plants with anthracite and coke; also one containing theoretical explanations and reference data.

CHURCH'S LABORATORY GUIDE.—A Manual of Practical Chemistry for Colleges and Schools, Specially Arranged for Agricultural Students. Revised and partly rewritten by Edward Kinch, F. I. C., etc., Professor of Chemistry in the Royal Agricultural College, Cirencester. Eighth Edition. New York: D. Van Nostrand Co. Cloth; 5 × 7⅛ ins.; pp. xvi. + 349; 42 illustrations in the text. $2.50 net.

As stated in the title page, this is a book primarily for students in agricultural colleges. Originally published in 1864 for use in the Royal Agricultural College, according to a statement in the preface, it has "been adopted not only in agricultural colleges in Great Britain, but also in Australia, India, Italy and Japan."

The book is a very comprehensive one, containing (1) instructions for some experiments in general chemistry, both inorganic and organic; (2) a scheme of qualitative analysis which omits everything not of interest to the agriculturist; (3) a system of quantitative analysis of important agricultural materials. The last division comprises more than half of the book. Practically all the illustrative exercises throughout the work are upon substances bearing directly upon agricultural questions. The third section takes up and deals very fully with manures and fertilizers, soils, waters and food. The student of agricultural science who desires a short chemical course restricted to his own field will find the present work of great value. Other chemical students will find other books better suited to their needs.

SHAFT SINKING IN DIFFICULT CASES.—By J. Riemer. Translated from the German by J. W. Brough, Assoc. M. Inst., C. E. London, England: Charles Griffin & Co. Philadelphia: J. B. Lippincott Co. Cloth; 6 × 9 ins.; pp. 122; 19 folding plates and 18 text illustrations. $3.50, net.

The principal aim of the volume is to give those in charge of mining undertakings a review of the various methods that may be used in difficult cases of sinking. The subject is divided into four parts: Shaft sinking by hand, by boring, the freezing method and the sinking drum process. As a translation it is most clearly worded, and the descriptions, especially of the Kind-Chaudron system of sinking by boring, are so good that one can almost see the process at work whilst reading the description. The author spares no pains to impress upon his readers that sinking by hand, where possible, is the very best method; and that sinking by any of the other three known methods—by boring, freezing (which renders the strata temporarily suitable for hand sinking), or the drum, should only be resorted to if the water to be contended with or the nature of the strata do not permit its use. He further states that where considerable difficulties have to be encountered, sinking by boring has always proved the cheapest method. The work concludes with a list of the more important special memoirs dealing with the subject of shaft sinking in cases of difficulty.—"The Mining Journal" (London).

WATER-WORKS MANAGEMENT AND MAINTENANCE.—By Winfred D. Hubbard, Assoc. M. Am. Soc. C. E., and Wynkoop Kiersted, M. Am. Soc. C. E., New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 6 x 9 ins.; pp. vi. + 429; 114 figures and 18 plates. $4.

The first 200 pages of this book are given up to the consideration of the methods and principles of developing, improving and storing water supplies, both ground and river supplies being discussed. The senior author has devoted many years to work along these lines, and he here sets forth the results of his experience, giving much attention to percolation and the purification of water by filtration and coagulation. One chapter is on the various types of pumping engines, in which their uses and adaptability to particular cases are explained. The second part of the work takes up the subjects of maintenance and operation, containing chapters on plans and records; extensions (including the cost of valves), fittings, approximate cost of laying cast-iron pipe; service connections; meters; care of appurtenances; alterations and repairs; maintenance of quality; water waste; electrolysis and its prevention; fire protection; accounts; financial management; rules and regulations; annual reports. In the closing part the subjects of franchises, water rates and depreciation are considered, much matter being given of great importance in connection with the subject of municipal ownership. The work deserves the attention of every one interested in the subject of water supply, and should find a place in the office library of every water-works official.

THE CONSTRUCTION OF DYNAMOS (Alternating and Direct-Current).—A Text-Book for Students, Engineer-Constructors, and Electricians-in-Charge. By Tyson Sewell, A. M. I. E. E., Lecturer and Demonstrator in Electrical Engineering at the Polytechnic, Regent St., London. London: Crosby Lockwood & Son. New York: D. Van Nostrand Co. Cloth; 5¼ x 8 ins.; pp. xii. + 386; 233 illustrations in the text. $3.00, net.

This work is an attempt to deal in a single volume with the theory, design and construction of both alternating and direct-current dynamos of the various types. While intended mainly for the use of students, it is thought that it will prove helpful to civil, mechanical and other engineers who have occasion to deal with electrical matters. The elementary principles are well stated, the explanations of alternating-current phenomena being especially clear. Chapters are devoted to the following subjects: Fundamental principles of direct currents; the magnetic field; the production of an electromotive force; fundamental principles of alternating currents; the alternating magnetic field; the capacity of the circuit; bi-polar-dynamo construction; theory of bi-poplar machines; bipolar-dynamo design; multi-polar-dynamo construction; multi-polar-dynamo design; single-phase alternators; construction of alternators; polyphase alternators; exciting, compounding and synchronizing of alternators.

RIVER DISCHARGE.—Prepared for the Use of Engineers and Students. By John Clayton Hoyt, Assoc. M. Am. Soc. C. E., Engineer in charge of Hydraulic Computations, U. S. Geological Survey, and Nathan Clifford Grover, Assoc. M. Am. Soc. C. E., Assistant Chief Hydrographer in charge of River Measurements, U. S. Geological Survey. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 6 x 9 ins; pp. viii. + 137; 23 illustrations. $2.

The authors of this work have been engaged for several years on hydrographic work for the United States Geological Survey, and have collated information in regard to the best practice on the flow of streams, water resources of the country available for domestic use, irrigation and power, etc., from their own experience as well as from other sources. Practice is emphasized rather than theory, the authors stating that in the case of the calculation of discharges the judgment of the engineer must be relied on to a large extent, a simple formula, with a rugosity coefficient dictated by his experience, giving as good results as a more complex one, especially in preliminary work. Chapters are included on rainfall and evaporation; instruments for measuring velocity; the selection of stations for taking velocity measurements; weir sections; discussion and use of data. A number of tables are appended for the purpose of facilitating calculations.

DENATURED OR INDUSTRIAL ALCOHOL.—A Treatise on the History, Manufacture, Composition, Uses and Possibilities of Industrial Alcohol in the Various Countries Permitting Its Use, and the Laws and Regulations Governing the Same, including the United States. By Rufus Frost Herrick, Consulting Chemist and Chemical Engineer, New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 5¾ x 9¼ ins.; pp. 516; 163 illustrations, mostly in the text. $4 net.

This is a worth-while book on a timely sub-

ject, being sufficiently technical for the chemist, yet adapted to the comprehension of the general reader. It opens with a historical sketch of the use of denatured alcohol in foreign countries, and follows this with chapters on raw materials, apparatus and processes employed in distillation and rectification. Other chapters take up the various methods of testing alcohol, and the cost of plants for manufacturing, as well as the cost of production. Chapters VI and VII treat respectively of the use of alcohol as an illuminant and as a fuel. The remaining chapters are devoted to alcohol as a source of power, methods of denaturing, and the future possibilities of alcohol in the industries. Appendixes are given up to regulations regarding the manufacture, sale, and use of denatured alcohol, a bibliography on the subject, and a list of patents on distilling and accessory apparatus.

THE BLACKSMITH'S GUIDE.—By J. F. Sallows, Brattleboro, Vt.: The Technical Press; 4½ × 7 ins.; pp. 160; 162 illustrations, 3 colored plates and one folding plate. Cloth, $1.50; leather, $2.00.

This is a compact book of practical instructions on forging, welding, hardening, annealing, brazing, etc., written by a foreman smith of 27 years' experience. The treatment throughout is of a thoroughly practical nature, and the author describes clearly the methods which he has employed in obtaining eminently satisfactory results in the tempering of tools and machine parts—all without the use of expensive furnaces, pyrometers and other accessories. Chapters are included on the following subjects: Machine Forging; Tool Forging; Hardening and Tempering; High-Speed Steel; Casehardening and Coloring; Brazing; General Blacksmithing. Tables of decimal equivalents and colored heat and temper charts as well as working drawings of a casehardening furnace are given in an appendix. It is a little work that anyone having to do with the heat-working of steel will find of exceeding value.

GAS AND OIL ENGINES AND GAS-PRODUCERS.—A Treatise on the Modern Development of the Internal-Combustion Motor and Efficient Methods of Fuel Economy and Power Production. Part I: Gas and Oil Engines. By Lionel S. Marks, S. B., M. M. E. Part II: Gas Producers. By Samuel S. Wyer, M. E. Chicago: American School of Correspondence. Cloth; 6½ × 9½ ins.; pp. 144; 93 illustrations in the text. $1.00.

This is the first of a series of handbooks on engineering subjects, prepared with the especial view of their adaptability to home study and self-instruction. The authors are men of acknowledged authority in their respective lines, and write more particularly regarding the practical, as distinguished from the merely theoretical or academic sides of their subjects, avoiding heavy technical terms and the use of higher mathematics. The work is divided into five chapters, namely: The Internal-Combustion Motor; Operation and Maintenance of the Gas Engine; Oil Engines; Gaseous Fuels; Manufacture of Producer Gas.

BALANCING OF ENGINES.—Steam, Gas and Petrol. An Elementary Text-Book. Using principally Graphical Methods. For the Use of Students, Draftsmen, Designers, and Buyers of Engines. By Archibald Sharp, Assoc. M. Inst. C. E. London, New York and Bombay: Longmans, Green & Co. Cloth; 5½ × 8¾ ins.; pp. 212; illustrated. $1.75, net.

The development of the gasoline motor-car engine, the successful installation of steam turbines and gas and oil engines for land and marine use have been the means of directing much attention to the subject of engine balancing. This book discusses in detail the methods of obtaining good balances of the inertia forces of engines, and also briefly considers the question of uniform torque on the crank-shaft. The treatment is largely graphical, and the author has included original methods which he believes will greatly facilitate the computations of engine designers. Exercises for the use of students are appended to nearly all of the chapters.

CLEAN WATER AND HOW TO GET IT.—By Allen Hazen, M. Am. Soc. C. E., Am. Water-Works Assn., etc. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 5⅛ × 7¼ ins.; pp. x. + 178; many half-tone illustrations. $1.50.

This little volume was written for the purpose of supplying accurate and up-to-date information for non-technical readers on the subject of water supply, and especially those who are charged with the responsibility of securing adequate and suitable supplies for their municipalities, as mayors, aldermen and other officials. Water supplies from lakes, rivers and ground sources are briefly discussed, together with the action of water on iron pipes and the effect thereof on the quality of the water. Various methods of filtration and purification are explained, and one chapter is given up to the use and measurement of water. The laying out and construction of works is touched on, and a short chapter on financial management of municipal plants is given in conclusion.

PROBLEMS IN STRENGTH OF MATERIALS.—By William Kent Shepard, Ph. D., Instructor of Mechanics in the Sheffield Scentific School of Yale University. Boston and New York: Ginn & Co. Cloth; 6 x 9½ ins.; pp. 70; illustrated. $1.25; by mail, $1.30.

This is a collection of nearly 600 problems, intended to supplement the usually insufficient number given in treatises on the strength of materials. It is the author's experience that a working knowledge of the subject is best obtained when the student is required to solve numerous problems, thus making practical application of the principles which he has learned. In addition to the problems is given a discussion of riveted joints for use in calculations pertaining to boiler design; tables at the back of the book contain all the data necessary for the solution of the problems given.

NEW BOOKS.

Civil Engineering.

BETON-KALENDER 1908.—Published by the Journal "Beton und Eisen," with the Cooperation of Prominent Technical Men. Third annual appearance. In two parts. Berlin, Germany: Wilhelm Ernst & Son. Part I. in cloth, Part II. in paper; 4 x 6½ ins.; pp. 328 + 468; 950 illustrations in the text and 1 plate. 4 marks; American price, $1.60.

EARTHWORK DIAGRAMS.—Giving Graphically the Cubic Contents for Different Heights of Banks and Cuttings, Either 66 Ft. or 100 Ft. Chains. By R. A. Erskine-Murray and Y. D. Kirton. 36 x 26 ins. London, England: Crosby Lockwood & Son. 5s., net; or mounted on card, 7½s., net. American price, $2, net; mounted on card, $3, net.

MASONRY CONSTRUCTION.—A Guide to Approved American Practice in the Selection of Building Stone, Brick, Cement, and Other Masonry Materials, and in All Branches of the Art of Masonry Construction. By Alfred E. Phillips, Ph.D., Professor of Civil Engineering, Armour Institute of Technology, and Austin T. Byrne, Author of "Highway Construction," "Materials and Workmanship." Chicago, Ill.: American School of Correspondence. Cloth; 6½ x 9¾ ins.; pp. 128; plates and text illustrations. $1.

RECUEIL DE TYPES DE PONTS POUR ROUTES EN CIMENT ARMÉ.—Calculated in Conformity with the Ministerial Order of Oct. 20, 1906. By N. de Tedesco, with the collaboration of Victor Forestier. From "Encyclopédie des Travaux Publics," begun by M.-C. Lechalas. Paris, France: Ch. Béranger. Paper; 6½ x 10 ins.; pp. 307; 54 illustrations in the text; 8 folding plates in separate atlas, 10½ x 12¾ ins. 25 francs; American price, $7.50.

ZAHLENBEISPIELE ZUR STATISCHEN BERECHNUNG VON BRUECKEN UND DAECHERN.—Prepared by Robert Otzen, Assistant at the Hannover Technical College, after the First Edition of F. Grages, Edited by G. Barkhausen, Professor at the Hannover Technical College. Second edition, revised and enlarged. Wiesbaden, Germany: C. W. Kreidel. Paper; 7¼ x 11 ins.; pp. 344; 3 plates and 329 text illustrations. 12 marks; American price, $4.80.

Electrical Engineering.

ELECTRIC RAILWAYS.—Theoretically and Practically Treated. By Sydney W. Ashe, B. S., E. E., Assoc. M. Am. Inst. E. E., Consulting Electrical Engineer. Department of Electrical Engineering, Polytechnic Institute of Brooklyn. Vol. II.: Engineering Preliminaries and Direct-Current Sub-Stations. New York: D. Van Nostrand Co. London, England: Archibald Constable & Co., Ltd. Cloth; 5 x 7¾ ins.; pp. 282; 145 illustrations, mostly in the text. $2.50, net.

EXPLANATIONS OF SWITCH AND SIGNAL Circuits.—A Hand-book of Diagrams and Information for Electrical Signal Constructors Maintainers. By John T. Doran. New York: Doran & Kasner. Flexible cloth, with flap; 4¾ x 6½ ins.; pp. 140; with 50 half-tone illustrations and diagrams. $1.50.

POWER STATIONS AND POWER TRANSMISSION.—A Manual of Approved American Practice in the Construction, Equipment and Management of Electrical Generating Stations, Substations and Transmission Lines, for Power Lighting, Traction, Electrochemical and Domestic Uses. Part I.: Power Stations. Part II.: Power Transmission. By George C. Shaad, E. E., Assistant Professor of Electrical Engineering, Massachusetts Institute of Technology. Chicago, Ill.: American School of Correspondence. Cloth; 6½ x 9¾ ins.; pp. 74; 10 plates and 41 text illustrations. $1.

Mechanical Engineering.

RATIONELLE KONSTRUKTION UND WIRKUNGSWEISE DES DRUCKLUFT-WASSERHEBERS FUER TIEFBRUNNEN.—By Alexander Perényi, Chief Engineer of the Royal Hungarian State Railways. Weisbaden, Germany: C. W. Kreidel. Paper; 7¼ x 10¾ ins.; pp. 52; 14 illustrations in the text. 2.40 marks; American price, 96 cts.

TECHNICAL EDUCATION AND COLLEGE NOTES

THE GENERAL ENGINEER

"In these days when so much has been said about specialization and about the necessity for any young man in the technical field to devote himself exclusively to a certain branch, it may be well to accentuate the point that specialization may be carried too far. The man who becomes too one-sided in his work may be useful to a less extent than he would have been had he, while making a particular study of a special field, devoted some time to broaden his intellect in various ways. The truly great men of this, as well as former ages, are men who have not confined themselves to a small sphere of usefulness. It is true that it will not do to divide one's interests between too many things at a time. Do one thing at a time, and do it well, but do not think that the time has come when general information in regard to all the things that surround us in life is useless simply because it is not possible to become a master of all the arts. Perhaps, on the other hand, there never was a time when the man with a broad view had a greater chance. The specialization in all lines of industry has limited the opportunities for the development of men of varied experiences, but such men are necessary for the executive positions. There is for this reason a premium on the services of the man who has been able to acquire a general, even if limited, knowledge of the industries, the business and other conditions outside of his own branch; and because such knowledge is becoming more scarce, as the specialization becomes more systematized, there is all the more reason for not being deluded by the general outcry that a man to be truly successful must be a specialist. To a certain limit the man who is a specialist, and nothing but a specialist, is more successful than his fellow-workers; but this is in the secondary positions, when he is working under the guidance of men who can supplement his lack of general development. When the moment comes that the place of managing the whole concern is to be filled, the specialist is left where he is, because he is filling his present place so exceeding well, and the man who never was thought much of where but one of his many faculties came into play, is promoted to the place where he can give full sway to his general knowledge and his varied interests; and the specialist who in his one-sidedness thinks that he was the person logically fit for the promotion, thinks himself badly ignored and his ability misunderstood; he does not realize that with all our specialization the 'all around man' still holds his own."—"Machinery."

"Each of you probably has a preconceived notion of following some line of engineering. Be careful about your self-analysis. The field is large and has room for all of the various types of men, some of whom incline to constructive operations, others toward inventive, some to the contemplative. Again, within all these divisions, some tend towards professional and others towards trade work. No one can advise what is best for you; this you must find out for yourself. I cannot help, however, a certain predilection in favor of a young man being just an engineer—not specializing while too young, but developing along versatile lines, ready to turn his hand equally well to any task within his general scope."—Walter C. Kerr, President of the Westinghouse, Church, Kerr & Co., in an address to the graduating class, Stevens Institute of Technology, June 16, 1904.

For the preparation of the "all around man" who is "just an engineer," some scheme of educational training would seem to be required which is broader in its scope than any that at present exists, so far as we are aware. In the four years that are devoted to the technical education of young men is it possible to instruct them, or the fittest of them, in the es-

sentials of mechanical, civil, electrical, mining, and metallurgical engineering? At first sight, no! But let us see.

In the schedule accompanying this article have been entered all of the various studies and laboratory exercises that are embodied in these five courses in one of the foremost engineering schools of the country, and against these items are set the number of hours devoted to each study or exercise. These courses, in their entirety, amount to 10,000 hours, and, at 48 hours a week, would require from the student seven of the 30-week years at this institution for their completion. Now, there are a number of high-grade technical schools in which the duration of the school year is 36 weeks, and one, at least, in which it is 37 weeks. Furthermore, the time devoted to study, recitations and laboratory work at these institutions is from 54 to 57 hours per week instead of the 48 just mentioned. In addition, these schools, or some of them, supplement their regular instruction by summer terms of from two to four weeks in length, which are chiefly devoted to field work or shop practice. Thirty-nine 57-hour weeks a year, therefore, are assumed for the purpose of these observations, and four such years amount in all to 8,892 hours.

The total number of hours given in the accompanying schedule is 8,880. This number is about 1,200 less than that required by the full courses. (Where a number is followed by one in parentheses, the latter is the full number of hours devoted to the study.) In all but three or four instances, however, the reduced number of hours given is greater than the time devoted to the subjects in at least one school of high standing; in the others the reduction is inconsiderable, for all practical purposes, leaving in each case at least 85% of the maximum time required for the subjects in a specialized course.

A graduate from a course similar to the one here outlined, would have "engineering perspective." By the time he was ready to receive his degree he would have become acquainted with the rudiments of the five great subdivisions of engineering, and have had a thorough training in the basic studies of mathematics, physics, chemistry, and drawing; he would then be prepared to develop along the line most fitted to his temperament and inclinations.

There are difficulties, of course, which would be encountered in the establishment of such a course. More instructors and much greater equipments would be necessary. These, however, are matters involving financial considerations—they do not affect the feasibility of the proposition, does it commend itself. If a demand arises for the "general engineer," enlightened philanthropists will no doubt be found who will provide the ways and means for meeting it. Meanwhile, the subject is one that merits exhaustive discussion.

A COURSE IN GENERAL ENGINEERING.

	Study, lectures and recitations.*	Laboratory work.	Drawing and field work.
General:			
Mathematics	750		
Physics	335	204	
Chemistry	240 (285)	456 (578)	
French	135 (270)		
German	240 (270)		
Applied mechanics	375		
Hydraulics	200 (255)	50	
Freehand drawing and descriptive geometry	45		180 (195)
Engineering laboratory	37	75	
Geology	300 (375)	60	
Materials	45		
Political economy	90		
Contracts, corporations, etc.	75		
Costs, management, etc.	30		
Civil Engineering:			
Bridge design			180
Geodesy	30		
Stereotomy			60
Structures, foundations	450 (525)		
Surveying			360 (435)
Astronomy	75		
Roads and pavements	30		
Railway design	30		60
Railway engineering	135 (180)		
Sewerage and water supply	180 (190)		
Electrical engineering	520 (600)	340 (400)	40
Mechanical Engineering:			
Dynamics of Machinery	75		
Hydraulic Machinery	75 (90)		
Shop work		450	
Steam engineering and thermodynamics	378 (405)		
Heating and ventilation	45 (90)		
Locomotive engineering	160 (225)		
Mechanism	200 (255)		
Machine design and drawing			435 (520)
Mining and metallurgy	400 (465)	250 (300)	
	5,680	1,885	1,315

Total, 8,880 hours.

*In the proportion of two hours study to each hour of recitation or lecture.

INDUSTRIAL ENGINEERING

A RECORD OF NEW TOOLS ~ PROCESSES AND APPLIANCES

The publication of material in this section is not paid for. While it partakes more or less of the nature of advertising of the firms mentioned, it is intended as review notices of some of the more important catalogues received describing new features in machinery, materials, processes, etc., of interest to the engineering profession.

ADVANTAGES OF AN AUTOMATIC CUT-OFF-VALVE AS SHOWN BY TESTS AND PRACTICAL EXPERIENCE.

By A. EUGENE MICHEL.

Such great damage is done by the occasional bursting of steam mains or the failure of boiler tubes, where there is high steam pressure, that some kind of excess flow safety-valve is essential for every boiler. There are many devices on the market which will prevent steam from flowing back from the mains into the boiler, but these valves make no provision against accident to the steam piping. The escape of steam would continue until the boiler were emptied. The valve which we are about to describe not only acts as a "non-return" valve, but it also shuts off the boilers

AUTOMATIC CUT-OFF VALVE.

with equal surety and protection if the main should be broken, as from water hammer or from the breaking of an elbow. As a cut-off valve it acts automatically, but by turning of a hand-wheel it may further be used as an ordinary stop-valve. As steam is raised in the boiler the valve opens it to the main when the boiler pressure is equal to the pressure in the line, thus avoiding all accidents from carelessly opening valves while there is considerable difference of pressure.

This valve works instantly either way and does not depend upon differences in pressure for its action, but upon the actual flow of steam through the valve. If a tube in one of the boilers should give way it shuts down that boiler only, and allows all the other boilers in the battery to go on supplying steam as usual. With an ordinary stop-valve the fireman is frequently scalded in trying to shut off the main or is driven from the fire room without being able to do anything to save the entire plant from shut down. This cut-off valve will, unless intentionally opened, stay closed until the pressure is raised again. It is, therefore, perfectly safe for a man to go inside to repair damages as soon as the injured boiler has cooled off sufficiently.

If, on the other hand, a steam header bursts, or a joint breaks or a cylinder head blows off the engine, the cut-off valves on all the boilers close immediately before the room has been filled with steam, and repairs can proceed at once. The operation of this valve may easily be seen from the accompanying cross-sectional view. It is installed so that the lower valve disc is toward the boiler and the hand-wheel on top. Normally, when the boiler is not working the upper valve rests upon the seat and prevents steam from the main from entering the boiler. When the steam pressure in the boiler is raised to slightly exceed that in the main, the valve lifts and steam flows from the boiler into the main. The valve is very nearly counterbalanced by a weight on an external arm. The leverage of this weight may be adjusted to different rates of steam flow and boiler output. The valve is operated not by pressure but by the actual flow of steam through it. The normal flow of

steam into the main raises the discs to mid-position as shown. The valve remains in that position as long as steam is being drawn from the boiler at the normal rate, but in case of a break on line side of the valve the excessive rush of steam would carry the lower valve up against the seat, shutting off the boiler. Of course, when the flow reverses the upper valve drops instantly to its seat and shuts off the steam. The rate of flow at which the boiler would be shut off is determined by the weight above mentioned, and by the distance between the two valve faces. This is adjusted

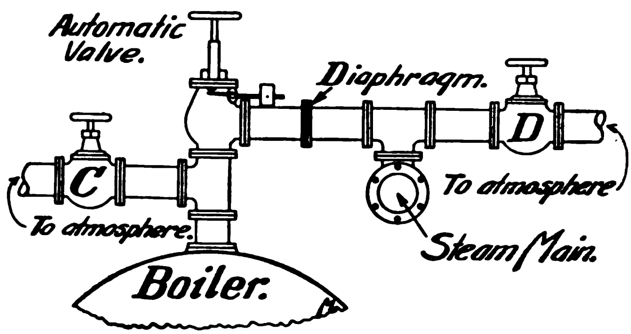
CROSS-SECTION OF AUTOMATIC CUT-OFF VALVE.

to correspond to the greatest over-load at which it is desired to operate the boiler, say, a rate over twice the normal rated capacity or when the water begins to raise in the gage glass.

A fork and link arrangement connect the valve discs and balancing lever positively, so that the position and condition of the valve may be determined by a glance at the balancing lever.

The balancing lever is provided with light springs which prevent the chattering or closing of the valve under ordinary conditions. The springs are not strong enough to prevent closing in case of accident, but will prevent closing in case of a momentary rush of steam. These springs can be adjusted to meet different quantities of flow of steam.

The following tests made on th[illegible] in the power house of the Anaconda, Mont., illustrate how it acts in case of accident. The accompanying illustration shows the arrangement for the test. The automatic valve was placed between the boiler and the main. On the boiler side was a connecting opening valve "C" communicating with the atmosphere, and on the main side was another quick opening valve "D," also opening to the atmosphere. The boiler was a 300-HP. Stirling water tube carrying a pressure of 150 lbs. When this pressure was reached the valve "D" was opened wide enough to allow steam to escape from the boiler to correspond with different rates of driving. To determine how the valve would act if the main should burst, the valve "D"



ARRANGEMENT OF VALVE FOR TESTS.

was thrown suddenly wide open. The water rose so rapidly in the glass that if it had been allowed to continue, it might have resulted in the destruction of the boiler. Before the water had gone up 2 ins., however, the automatic valve closed tight. A test was then made to see if the automatic valve would close if the break opened slowly. A steel diaphragm was placed in the pipe as shown; in this diaphragm was an opening 1⅝ ins. in diameter, and when the valve "D" was opened suddenly, the automatic valve closed promptly. This diaphragm was then removed and another substituted with an orifice 1½ ins. diameter. When the valve "D" was opened again, the automatic valve did not close, showing that its point of closing was between these rates of delivery. In this case it was set to close at a flow corresponding to 600 boiler HP.

After making these tests the boiler was again placed in service and a test was made to see what would happen if a boiler tube should break or some part of the boiler give way. This was done by suddenly opening valve "C" upon which the automatic valve

closed promptly, shutting off the main. Fifty-four tests like these were made and the valve acted perfectly each time. The tests were so satisfactory that 16 of these valves were installed in the plant.

The manufacturers frequently receive reports of accidents where the valve more than pays for itself in one emergency. One of these valves had hardly been installed in a plant recently when a blind end blew off the steam header. The engineer had forgotten to put in all the bolts but the automatic valve acted before further damage could be done.

Bursting steam pipes frequently scald their victims to death where there is no automatic means of shutting off the flow, but the danger in refrigerating plants is even greater. Just what ammonia will do if the flow is not stopped by a cut-off valve, may be judged from accidents which have happened at Armour's refrigerating plant in Chicago. A cylinder head blew off an ice machine last January while twenty men were in the room. Three were killed, sixteen overcome by the fumes before they could get out and only one escaped. In May, a two-inch ammonia pipe burst and the fumes killed six men, 200 head of cattle and a thousand sheep. The ammonia fumes were so strong that rescuers could not enter for four hours. A cut-off valve in the line would have checked the fumes in both instances before enough had escaped to be serious.

The automatic cut-off valve herein described and referred to is made by the Lagonda Manufacturing Company, Springfield, Ohio, who will furnish promptly any further descriptive literature desired upon request.

HYDRAULIC RAM PUMPING PLANTS.

The general idea of a hydraulic ram is that it is a small machine suitable only for raising a small quantity of water for country places, etc., but in reality there is practically no limit to the capacity of this type as now built, with automatic air-feeding device and highest efficiency. It has the advantage of possessing only a few wearing parts—easily and cheaply renewable—and operates without attention or expense. A modern ram as made by the Rife Engine Co. of New York City will pump with good efficiency against heads of 25 to 30 times the fall, the efficiency varying from 60 to 90% in proportion to the ratio of the fall to the pumping head. They will operate under two or more feet fall and elevate the water 25 to 30 ft. for each foot of fall used.

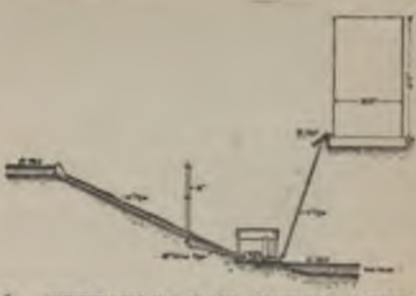


FIG. 1. HYDRAULIC RAM INSTALLATION FOR U. S. NAVAL COALING STATION, NARRAGANSETT BAY, R. I.

Figs. 1 and 2 show an installation of large Rife rams for the United States government

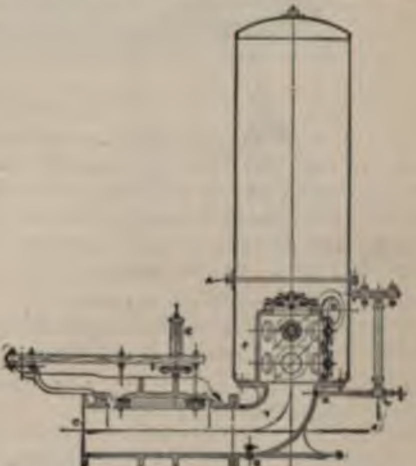


FIG. 2. RIFE RAM INSTALLED FOR U. S. GOVERNMENT.

coaling station at Narragansett Bay, R. I., each ram delivering 232 gals. per minute, an

FIG. 3. INSTALLATION OF HYDRAULIC RAM FOR FARMING PURPOSES.

FIG. 4. INSTALLATION OF RIFE HYDRAULIC RAM FOR FARMING PURPOSES.

efficiency of 91.25%. The efficiency guaranteed in the contract was 70%, but the tests showed mean results in excess of this, as follows:

	No. 1.	No. 2.
Total water delivered to engine, gallons per minute	582	578
Water delivered to stand-pipe, gallons per minute	232	228
Power head in engines, feet	36.75	37.25
Pumping head in feet	84.0	84.0
Strokes per minute	130	130
Efficiency, per cent. (D'Aubisson formula)	91.23	89.06

A plant recently installed at Kalispell, Mont. (water supply 800 gals. per min., 18 ft. fall, 159 ft. pumping head), delivers 80 gallons per minute, the water being supplied to the Conrad Memorial Cemetery, 85 acres, 50 acres being improved and provided with mains for irrigation.

These machines are now being adopted by the railroads to supply their water stations for locomotives, and the expense of attendants for steam plants, the fuel, etc., is eliminated.

Land lying above the irrigation canals, often of the finest kind but valueless for lack of water, can be made more valuable than the land below the ditch by utilizing the fall and water from the ditch to operate the ram, thus delivering a portion of this water to an upper ditch or reservoir.

Figs. 3 and 4 show the simple method of installation of small plants for country residences, stock farms, etc.

MOTORS FOR OPERATING VENTILATING APPARATUS.

The illustration given herewith shows the round type of direct-current electric motor, which has been developed by the Sprague Electric Co. for use in connection with fans and blowers for the ventilation of buildings.

These motors are bipolar, and have a single field coil which energizes both pole pieces. This coil is wound on a cylindrical brass spool having fiber ends or heads, and is surrounded and protected by the yoke. Owing to this protection the usual taping, which is detrimental in that it confines the heat, can be omitted. The heat developed by the exciting current is therefore quickly dissipated into the surrounding air, and as a result the life of the coil is greatly prolonged.

The armature core is thoroughly laminated, insuring low core loss and non-heating, and the armature windings for motors of one horse-power and over consist of insulated form-wound coils slipped into slots and retained by wooden wedges. The commutator is built up with a relatively large number of hard-drawn copper segments, and these, together with the finely divided armature winding and the generous dimensions of the commutator and brushes, afford excellent commutation and overload capacity.

These motors are very compact, requiring little space, whether they are belted or direct-

connected to the ventilating apparatus. They have a high efficiency and remarkable durability. Although designed to be enclosed, they can be operated as open motors by simply leaving off the two doors which give access to the commutator and brushes. The illustration

ROUND-TYPE MOTOR, WITH ONE DOOR REMOVED.

shows the motor with one door removed. Self-aligning and self-oiling bearings insure easy running and an uninterrupted lubrication of the parts.

These motors are made in nine different sizes of frames, ranging from ¼ to 7½ horsepower; they are designed for 115, 230, or 500 volts, and can be shunt, series or compound wound. They can be attached to the floor, wall or ceiling, as occasion may require, and direct-connected to the fan or blower. They can also be made to operate with the shaft in a vertical position. Motors for direct-connection to fans are different from the standard motors in having a longer shaft of larger diameter, extra heavy bearing next to fan, thrust bearing, etc.

ARTIFICIAL EMERY.

The invention of alundum is one of the latest of the important electrochemical inventions which, during the past few years, have attracted so much attention and made Niagara Falls the centre of electrochemical industry in the United States.

The introduction of alundum in the field of grinding has been remarkably successful and rapid. The requisites sought for and attained in this abrasive are extreme hardness and sharpness, combined with uniformity and proper temper. These qualities in alundum have had much to do with its successful development.

The process of making alundum consists in taking the purest amorphous oxide of aluminum found in nature, and known as the mineral bauxite, purifying and melting it in immense electric furnaces, the power for which is furnished by the Falls of Niagara. Upon cooling, this molten mass solidifies in solid ingots of alundum. Beautiful crystals are found in the centre of these masses, showing nearly all the variety of colors found in the ruby and sapphire, of which alundum is one variety.

After the ingots of alundum have cooled they are broken up and the pieces are then reduced to smaller pieces by means of powerful crushers. After this reduction the material is then shipped to the Worcester plant, where it is still further reduced by being passed through smaller crushers and several sets of rolls, in order to bring it into the many sizes of grains which are required in the manufacture of grinding-wheels. After passing through rolls, it is subjected to the usual washing and drying processes to prepare it for manufacture into grinding-wheels, rubbing and sharpening stones, and other articles.

The solid, massive alundum, while resembling the purest natural corundum in chemical composition, has the remarkable quality of being considerably harder than the natural product. This is due to the perfectly fluid condition in which the mass is brought, the control of its composition, the rate and method of its cooling and solidifying by which it receives its temper, the absence of water of combination (which almost invariably exists in natural corundum).

In the matter of hardness the recognized standard is the diamond, which is No. 10 in the scale of hardness. Pure crystalline corundum, represented by the best sapphire or ruby, has always been the standard for No. 9 in the scale of hardness. This is readily scratched by alundum.—From a booklet issued by the Norton Company, Worcester, Mass.

TRADE PUBLICATIONS.

STEEL MINE TIMBERS.—Data and Tables for the Use of Mining Engineers. Carnegie Steel Co., Pittsburg, Pa. Paper; 5 × 7½ ins.; pp. 38; illustrated.

It is stated in this pamphlet that wooden timbers used in anthracite mines have to be replaced every 12 to 18 months, this replacement being looked upon as an annual fixed charge, growing each year on account of the

steady increase in the price of timber—nearly 50% greater in 1906 than in 1905. In view of this the Carnegie Steel Co. has brought out an H-section of steel, which, in connection with the ordinary forms of I-beams and channels, may be used in several types of construction which have been successfully employed in mining work. This pamphlet illustrates a number of these systems of timbering, and gives tables of the properties of H-sections both as beams and struts, properties of I-beams, channels, and square and round timbers of oak, pine, spruce and hemlock, both as beams and posts, and other pertinent information.

REINFORCED CONCRETE IN FACTORY CONSTRUCTION.—6 × 9 ins.; 250 pp.; 159 illustrations. Published by The Atlas Portland Cement Company, 30 Broad St., New York City.

The use of reinforced concrete is becoming so popular on account of the advantages it possesses over other types of construction of permanence, economy and proof against fire, and its development has been made and is so rapid that any book giving new information is bound to meet with a cordial welcome and a ready demand.

In the present instance, the publishers have embraced the opportunity offered by this widespread interest, to issue a book which combines the feature of a trade publication and an important treatise on the subject of reinforced concrete in its special application to the construction of factory and warehouse buildings. They have not attempted to make it a "complete" treatise on concrete factory construction, but have aimed to present details of this method of construction and careful descriptions of typical examples of concrete buildings selected from various sections of the country and erected by representative builders, which will give a comprehensive idea of the advantages and limitations of the material. Suggestions are thus offered to the factory owner who contemplates building in reinforced concrete, while at the same time the practical details will prove of value to architects, engineers, and builders who are not concrete experts.

The book contains fourteen chapters treating of Factory Construction, Concrete Aggregates, Details of Construction, and descriptions of ten modern and important buildings.

Many of the styles and systems of reinforcement in common use in building construction are described in more or less detail with illustrations, and references are made to exampl[illegible] of concrete block walls, surface finish, e[illegible] pile foundations, and tanks. A number of details are shown which seldom appear in published descriptions of buildings, and care has been taken throughout to give complete measurements so that the figures may be used as a guide to new construction work.

At the close of the book The Atlas Portland Cement Company presents letters received by them from the owners of the plants described in the various chapters. A number of photographs of other reinforced concrete factories are also reproduced, without detail descriptions.

The work has been prepared for the publishers by Mr. Sanford E. Thompson, a consulting engineer well qualified to treat the subject as an expert authority. It may be considered as one of the best examples of the new idea of making a trade publication serve the double purpose of a compendium of practical information and of a medium of publicity. The book is offered for sale, bound in cloth, at fifty cents, but complimentary copies in board covers will be sent on request, to engineers, architects, builders and others interested in cement and concrete work.

"DRAGON" PORTLAND CEMENT.—The Lawrence Cement Company of Pennsylvania, 1 Broadway, New York. Paper; 5¼ × 8 ins.; pp. 126; illustrated.

This handsome booklet, just issued, gives a volume of interesting information regarding Portland Cement; its historical development from the earliest use of "Hydraulic Lime"; the invention of "Portland" Cement; the discovery of the cement rock in Pennsylvania from which grew the American Portland Cement industry to its present proportions of over fifty millions of barrels a year; the limits of the normal composition of Portland Cement and the use of this pure rock in the manufacture of "Dragon" Portland Cement.

It contains a chapter on the "Uses and Economies of Portland Cement," giving ideas of value and showing how extensively and economically it can be used for an almost infinite variety of constructive and unusual work.

Sections are devoted to Directions for Testing, Laboratory Tests, Packing and Shipment, and miscellaneous general information; seven pages are used for a listing of important works in which "Dragon" Portland Cement has been used, and a number of illustrations of public and private works are given, together with descriptive details and a large number of letters from builders and owners. The pamphlet is [illegible] an etched cover.

INDEX TO TECHNICAL ARTICLES IN CURRENT PERIODICAL LITERATURE

This Index is intended to cover the field of technical literature in a manner that will make it of the greatest use to the greatest number—that is, it will endeavor to list all the articles and comment of technical value appearing in current periodicals. Its arrangement has been made with the view to its adaptability for a card-index, which engineers, architects and other technical men are gradually coming to consider as an indispensable adjunct of their offices.

Each item gives:

1. Title and author.
2. Name and date of publication.
3. An estimate of length of article.
4. A short descriptive note regarding the scope of the article—where considered necessary.
5. Price at which we can supply current articles.

The Publishers do not carry copies of any of these articles in stock, but, if desired, will supply copies of the periodical containing the article at the prices mentioned. Any premium asked for out-of-date copies must be added to this price.

The principal journals in the various fields of technical work are shown in the accompanying list, and easily understood abbreviations of these names are used in the Index.

The Editor cordially invites criticisms and suggestions whereby the value and usefulness of the Index can be extended.

In order to comply with the many suggestions and requests of readers who desire to make practical use of this index, it will hereafter be printed on one side of the sheet only, to permit the clipping of any desired items.

LIST OF PERIODICALS INDEXED

JOURNALS, PROCEEDINGS AND TRANSACTIONS OF AMERICAN TECHNICAL SOCIETIES

Journal Am. Foundrymen's Assn.
Journal Assoc. Engineering Societies.
Journal Eng. Soc. of Western Pa.
Journal Franklin Institute.
Journal West. Society of Engineers.
Proceedings Am. Soc. C. E.
Proceedings Can. Soc. C. E.
Proceedings Engineers' Club, Philadelphia.
Proceedings New York R. R. Club.
Proceedings Pacific Coast Ry. Club.
Proceedings St. Louis Ry. Club.
Proceedings U. S. Naval Institute.
Transactions Am. Inst. Electrical Engineers.
Transactions Am. Inst. Mining Engineers.
Transactions Am. Soc. Mechanical Engineers.

(Continued on second page following.)

TECHNICAL PERIODICALS

An inch card under this heading costs $2.50 a month

American Builders Review

A Journal Devoted to the Architects, Contractors, Engineers and Builders of the Pacific Coast.

$5.00 per annum in the U. S.—Other Countries, $6.00. Single copies, 50 cents.

648 Stevenson St., SAN FRANCISCO, CAL.

The Canadian Municipal Journal

Official Organ of the Dominion and Provincial Unions of Municipalities.

Reaches the officers of EVERY municipality in Canada.

Monthly, one dollar per year; ten cents per copy.

Room 29, Alliance Building,
MONTREAL, CANADA.

Compressed Air

Monthly, devoted to the theory and practice of compressed air, pneumatic tools, air compressor design, air lift pumping, tunneling, rock excavation, etc.

10c. per copy. $1.00 per year.

Published by
THE COMPRESSED AIR MAGAZINE CO.,
Bowling Green Bldg., NEW YORK CITY.

Electric Railway Review

Best edited, most up-to-date and rapidly-growing journal in the traction field. Published every Saturday. Domestic, $2.00; Canada, $3.50; other foreign countries, $5.00; single copies, 10 cents.

THE WILSON COMPANY,
160 Harrison St., Chicago. 150 Nassau St., New York.
1529 Williamson Bldg., Cleveland, O.

Engineering-Contracting

A Weekly Journal for Civil Engineers and Contractors; with which is incorporated

ENGINEERING WORLD and CONTRACT NEWS.

Established 1891—Every Wednesday—$2 a Year.
Single copies 10 cents.

353 Dearborn St., CHICAGO, ILL.

Engineering News

A Journal of Civil, Mechanical, Mining and Electrical Engineering.

Weekly, $5.00 per year; single copies, 15 cents.
Published every Thursday by

THE ENGINEERING NEWS PUBLISHING CO.,
220 Broadway, NEW YORK.

The Industrial Magazine

A Monthly Magazine on Industrial Engineering for Engineers and Contractors.

Single copies 10 cents. One year $1.00

21 Park Row, NEW YORK.

The Iron Age

A Journal of the Iron, Steel, Metal, Machinery and Hardware Trades.

Subscription Price, $5.00 per year in the United States and Mexico; $7.50 in all other countries. Single copies 15 cents.

DAVID WILLIAMS CO.,
14-16 Park Place, NEW YORK.

Progressive Age

Treats of Gas and its application to domestic and industrial operations. Subscription $3. Specimen copy, 15 cents.

280 Broadway, NEW YORK.

Ores and Metals

A Semi-Monthly Review of Progress in Mining and Metallurgy.

$2.00 a year. 10 cents a copy.

DENVER, COLO.

The Railway Age

Leader and acknowledged authority in all steam railway matters. Published every Friday; over 2,000 pages a year. Domestic, $4.00; Canada, $5.50; other foreign countries, $6.00; single copies, 10 cents.

THE WILSON COMPANY,
160 Harrison St., Chicago. 150 Nassau St., New York.
1529 Williamson Bldg., Cleveland, O.

Roadmaster and Foreman

Established 1885.

For Roadmasters and Foremen, Engineers and Superintendents of Maintenance of Way, Superintendents and Foremen of Bridges and Buildings.

Monthly, $1.00 per year; single copies, 10 cents.

353 Dearborn St., CHICAGO, ILL.

AMERICAN AND CANADIAN PERIODICALS

Acetylene Journal.
American Architect.
American Artisan.
American Builders' Review.—See Adv. opposite.
American Carpenter & Builder.
American Engineer and R. R. Journal.
American Exporter.
American Gas Light Journal.
American Inventor.
American Journal of Science.
American Machinist.
American Shipbuilder.
Architect & Engineer of California.
Architectural Art.
Architectural Record.
Architectural Review.
Architects' and Builders' Mag.
Architecture.
Automobile.
Boiler Maker.
Brass World.
Brick.
Bulletin Am. Iron & Steel Assn.
Bulletin of Dept. of Labor.
Bulletin Univ. of Kansas.
Bulletin Univ. of Wisconsin.
California Journal of Technology.
Canadian Architect.
Canadian Cement & Concrete Review.
Canadian Electrical News.
Canadian Engineer.
Canadian Machinery & Manufacturing News.
Canadian Manufacturer.
Canadian Mining Journal.
Canadian Municipal Journal.—See Adv. opposite.
Carpentry and Building.
Cassier's Magazine.
Castings.
Cement.
Cement Age.
Cement and Engineering News.
Cement Era.
Central Station.
Chemical Engineer.
Cold Storage and Ice Trade Journal.
Commercial America.
Compressed Air.—See Adv. opposite.
Concrete.
Concrete Age.
Concrete Engineering.
Contractor.
Consular and Trade Reports.
Cornell Civil Engineer.
Domestic Engineering.
Economic Geology.
Electrical Age.
Electrical Review.
Electric Journal.
Electric Railway Review.—See Adv. opposite.
Electrical World.
Electric Traction Weekly.
Electrochemical and Metallurgical Industry.
Engineer.
Engineering-Contracting.—See Adv. opposite.
Engineering and Mining Journal.
Engineering Magazine.
Engineering News.—See Adv. opposite.
Engineering Record.
Engineer's Review.
Far Eastern Review.
Fire and Water Engineering.
Forestry and Irrigation.
Foundry.
Gas Engine.
Glass and Pottery World.
Hardware.
Heating and Ventilating Magazine.
Horseless Age.
Ice and Refrigeration.
Illuminating Engineer.
Implement Age.
Industrial Magazine.—See Adv. opposite.
Industrial World.
Inland Architect.
Insurance Engineering.
International Marine Engineering.
Iron Age.—See Adv. opposite.
Iron Trade Review.
Irrigation Age.
Journal of Electricity, Power and Gas.
Journal of U. S. Artillery.
Journal of Worcester Polytechnic Institute
Judicious Advertising.
Machinery.
Marine Review.
Metal Industry.
Metal Worker, Plumber and Steam Fitter.
Mines and Minerals.
Mining and Scientific Press.
Mining Reporter.
Mining World.
Modern Machinery.
Moody's Magazine.
Motor.
Motor Age.
Motor Boat.
Motor Car.
Motor Traffic.
Municipal Engineering.
Municipal Journal and Engineer.
Ores and Metals.—See Adv. opposite.
Paper Trade Journal.
Plumber's Trade Journal.
Popular Mechanics.
Popular Science Monthly.
Power.
Power and Transmission.
Power Wagon.
Practical Engineer.
Printers' Ink.
Progressive Age. See Adv. opposite.
Railroad Gazette.
Railway Age.—See Adv. opposite.
Railway and Engineering Review.
Railway and Locomotive Engineering.
Railway and Marine World.
Railway Engineering.
Railway Master Mechanic.
Roadmaster and Foreman.—See Adv. opposite.
Rose Technic.
Scientific American.
Scientific American Supplement.
Selling Magazine.
Sibley Journal of Engineering.
Southern Machinery.
Stevens Institute Indicator.

Stone.
Street Railway Journal.
Technical World Magazine.
Technology Quarterly.
Textile Manufacturer's Journal.
Tradesman.
Waterproofing.
Western Electrician.
Wood Craft.
Wood Worker.

PRINCIPAL BRITISH PERIODICALS

Agricultural Chronicle. (m.) London.
Architect. (w.) London.
Architects' Magazine. (m.) London.
Architectural Review. (m.) London.
Autocar. (m.) London.
Automobile Journal. (m.) London.
Automotor Journal. (w.) London.
Board of Trade Journal. (w.) London.
British Architect. (m.) London.
British Clay Worker. (m.) London.
British Trade Review. (m.) London.
Builder. (w.) London.
Building Industries. (w.) Glasgow.
Civil Engineering. (w.) London.
Cold Storage. (m.) London.
Colliery Guardian. (w.) London.
Commercial Motor. (w.) London.
Concrete & Constr. Engg. (b-m.) London.
Contract Journal. (w.) London.
Electrical Engineer. (w.) London.
Electrical Engineering. (w.) London.
Electrical Magazine. (m.) London.
Electrical Progress. (m.) London.
Electrical Review. (w.) London.
Electrician. (w.) London.
Electricity. (w.) London.
Engineer. (w.) London.
Engineering. (w.) London.
Engineering Review. (m.) London.
Engineering Times. (w.) London.
Engineering World. (w.) London.
Engineers' Gazette. (m.) London.
English Mechanic. (w.) London.
Gas and Oil Power. (m.) London.
Gas Engineers' Magazine. (m.) London.
Implement and Machinery Rev. (m.) London.
India Rubber World. (m.) London.
Iron and Coal Trades Review. (w.) London.
Iron and Steel Trades Journal. (w.) London.
Ironmonger. (w.) London.
Ironmongers' Chronicle. (m.) London.
Journal of Gas Lighting. (w.) London.
Journal of Society of Arts. (w.) London.
Locomotive Magazine. (m.) London.
Marine Engineer. (m.) London.
Mariner. (m.) London.
Mechanical Engineer. (w.) Manchester.
Mechanical World. (w.) Manchester.
Mining Engineering. (m.) London.
Mining Journal. (w.) London.
Mining World. (w.) London.
Motor. (w.) London.
Motor Boat. (w.) London.
Motor Car Journal. (w.) London.
Motoring Illustrated. (m.) London.
Municipal Journal. (m.) London.
Nature. (w.) London.
Oil Trades Gazette. (m.) London.
Page's Weekly. (w.) London.
Paper Maker. (m.) London.
Paper Making. (m.) London.
Petroleum World. (m.) London.
Practical Engineer. (w.) London.
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The Second International Aeronautic Race for the Bennett Trophy. Eng News—Nov 14, 07. 3 figs. 1400 w. 20c. Gives barometer records of the "United States" and the "Pommern."

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Brass Castings for Automobiles. E. F. Lake. Fdry—Nov, 07. 5 figs. 2800 w. 20c. Discusses the alloys used for special motor-car parts—casting for carburetor body.

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Automobile Change Gears and their Journals. Henry Hess. Am Mach—Oct 31, 07. 25 figs. 2200 w. 20c. Discusses their design. A paper presented to the Society of Automobile Engineers.

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Simultaneous Braking of all Four Wheels. P. D'Estival. Automobile—Nov 14, 07. 5 figs. 1200 w. 20c. Translated from "La Vie Automobile," Paris, by Charles B. Hayward.

New Motor Cars.

Motor-Car Exhibition at Olympia.—I. Engr (Lond)—Nov 15, 07. 15 figs. 6000 w. 40c.

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A Reinforced Concrete Bridge Abutment, its Design and Specification. T. M. Fyshe. Can Cem & Conc Rev—Nov, 07. 4300 w. 20c.

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The Compressive Member. Horace E. Horton. Ry & Eng Rev—Nov 2, 07. 7 figs. 4200 w. 20c. Discusses the Quebec Bridge failure.

The Quebec Bridge. Alfred J. Roewade. Can Engr—Nov 1, 07. 3 figs. 1800 w. 20c.

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A New Method of Condensing and Scrubbing. Wm. Seymour. Prog Age—Nov 15, 07. 2 figs. 6000 w. 20c. Paper read before the Mich. Gas Assn., Sept 20, 07.

Filling Balloons. W. A. Baehr. Prog Age—Nov 15, 07. 4 figs. 4200 w. 20c. Describes the supplying of gas for the International balloon races at St. Louis, Oct. 21, 07.

Gas Standards. Alfred E. Forstall. Prog Age Nov 1, 07. 2800 w. 20c. Paper read before the Empire State Gas & Elec. Asso., Oct. 2, 07.

High Pressure Distribution: Its Effect on the Illuminating and Calorific Powers of Gas. Am Gas Lt Jl Oct. 28, 07. 1400 w. 20c. From the "Journal of Gas Lighting."

Home-made Hoisting Devices in the Gas Works. Am Gas Lt Jl Nov 11, 07. 6 figs. 1200 w. 20c.

Studies in the Manufacture of Coal Gas. Alfred H. White and Fred. E. Park. Prog Age—Nov 15, 07. 6 figs. 7200 w. 20c. Paper read before the University of Mich., Sept. 20, 07.

Graphite (Deflocculated).

Deflocculated Graphite. E. G. Acheson. Jl of Franklin Inst—Nov, 07. 5 figs. 3200 w. 60c. Paper read before the Institute, Oct., 07.

Deflocculated Graphite. E. G. Acheson. Am Mach—Nov 21, 07. 1 fig. 1600 w. 20c. Abstract of an address delivered in New York before the American Electrochemical Society.

Nitric Acid.

Synthetic Nitric Acid. Eng & Min Jl—Nov 16, 07. 1100 w. 20c.

Zinc Pigment.

Zinc Oxide: Its Properties and Uses.—I. W. G. Scott. Min Wld—Nov 9, 07. 2600 w. Nov 16. 2700 w. Each. 20c.

MARINE ENGINEERING

Collier.

Coal-Carrying "Trunk" Steamer. Engg—Nov 1, 07. 2 figs. 1000 w. 40c.

Electric Conductors on Board Ship.

Electricity on Board Ship. Sydney F. Walker. Mar Engr & Nav Arch—Nov 1, 07. 2 figs. 2700 w. 40c. XIV.—Sizes of Cables for Distributing the Current.

"Kronprinzessin Cecilie."

The Hamburg-American Steamer "Kronprinzessin Cecilie." F. C. Guenther. Inter Mar Engg—Dec, 07. 19 figs. 3700 w. 40c.

Marine (Beam) Engines.

The Marine Type of Beam Engines. R. C. Monteagle. Tech Quarterly—Sept, 07. 4200 w. 80c.

"Mauretania."

The Cunard Turbine-Driven Quadruple-Screw Atlantic Liner "Mauretania." Engg—Nov 8, 07. A 90-page exhaustive description of the sister-ship to the "Lusitania," with 190 illustrations, 50 of which are full-page plates. Price, 80c. (It is doubtful whether orders can be filled for this number, as the issue describing the "Lusitania" was exhausted before our first order was received by the publishers.)

The Quadruple Turbine Steamship "Mauretania." Sc Am—Nov 23, 07. 8 figs. 3000 w. 20c.

Mine-Laying Steamer.

A New Mine-Laying Steamer. Inter Mar Engg—Dec, 07. 12 figs. 1800 w. 40c.

Navigation.

Navigation by Celestial Observation.—III. Stephen P. M. Tasker. Inter Mar Engg—Dec, 07. 2400 w. 40c.

Screw Propeller.

The Screw Própeller.—XV. A. E. Seaton. Mar Engr & Nav Arch—Nov 1, 07. 3200 w. 40c.

"Suevic," Repairs of.

A New Fore-Part for the "Suevic." Inter Mar Engg—Dec, 07. 5 figs. 900 w. 40c.

The Salvage of the Twin-Screw White Star Liner "Suevic." Mar Engr & Nav Arch—Nov 1, 07. 5 figs. 1500 w. 40c.

Turbine Steamer Tests.

Builders' Trials of Curtis Turbine Steamer "Creole." Chas. B. Edwards. Engg—Nov 15, 07. 900 w. 40c. Abstracted from the Journal of American Society of Naval Engineers.

Yarrow & Co.'s Shipyard.

The New Ship-building Works of Yarrow & Co., Limited, at Scotstoun. Engr (Lond)—Nov 15, 07. 4 figs. 7000 w. 40c. Describes new works on the Clyde.

MECHANICAL ENGINEERING

AIR MACHINERY.

Air-Compressors.

Electrically Driven Air-Compressors. Andrew F. Bushnell. Eng & Min Jl—Nov 2, 07. 6 figs. 2500 w. 20c.

The General Electric Centrifugal Air-Compressor. Sanford A. Moss. Ir Age—Nov 14, 07. 3 figs. 3200 w. 20c.

Air Drill.

The Electric Air Drill. William L. Saunders. Comp Air—Nov, 07. 2 figs. 6400 w. 20c. Presented at the Toronto meeting (July, 1907) of the American Institute of Mining Engineers.

Blowing Engines.

Blowing Engines Driven by Blast-Furnace Gas. Engg—Oct 25, 07. 13 figs. 1700 w. 40c.

FOUNDING.

Cost System for Foundry.

A Jobbing Foundry Cost System. J. F. Johnson. Fdry—Nov, 07. 10 figs. 3600 w. 20c.

Faults of Iron Castings.

Faults of Iron Castings.—II. Forrest R. Cardullo. Machy—Nov, 07. 2 figs. 2[illegible] w. 40c. Discusses sponginess, shrink-holes, floating cores, cold shuts, etc., from the machine designer's standpoint.

Malleable Fittings.

Production of Malleable Fittings. Fdry—Nov, 07. 22 figs. 4600 w. 20c.

Melting.

Economy in Melting. Jos. H. Hart. Met Ind—Nov, 07. 2000 w. 20c.

Melting Iron for Foundry Purposes.—II. E. L. Rhead. Mech Engr—Nov 2, 07. 3900 w. 40c.

Pouring.

Gates and Risers or Sink-Heads. P. R. Ramp. Fdry—Nov, 07. 10 figs. 1400 w. 20c.

Retort Casting.

Molding a Retort Casting. Jabez Nall. Fdry—Nov, 07. 10 figs. 2800 w. 20c.

Sand.

Preparation, Proportioning and Testing of Foundry Sand. J. Kraus. Stahl u Eisen Oct 23, 07. 8 figs. 2000 w. Oct 30, 07. 1000 w. Each, 60c.

Solidification of Cast Iron.

The Solidification of Cast Iron. E. L. Rhead. Fdry—Nov. 07. 3,300 w. 20c. Discusses changes occurring during and after cooling—crystallization and contraction.

Steel Castings.

Converter vs. Small Open-Hearth. W. M. Carr. Fdry—Nov. 07. 2200 w. 20c. Discusses the advantages and disadvantages of these two processes for the manufacture of small steel castings.

Titanium in Steel and Iron.

Titanium in Steel and Iron. Charles V. Slocum. Iron Tr Rev—Nov. 14, 07. 3000 w. 20c. A paper read before the Pittsburg Foundrymen's Association, Nov. 4, 1907.

HEATING AND VENTILATION.

Heating and Ventilating Installations.

Heating and Ventilating the Commercial National Bank Building.—II. Eng Rec—Nov. 2, 07. 3 figs. 3700 w. 20c.

The Mechanical Ventilation and Warming of St. George's Hall, Liverpool.—II. Htg & Vent Mag—Nov., 07. 2 figs. 500 w. 20c.

Hot-Blast Heating.

Hot-Blast Heating. Charles L. Hubbard. Dom Engg—Nov., 2, 07. 5 figs. 2000 w. Nov. 16. 1000 w. Each, 20c.

Indirect Heating in a Detroit Factory. Met Wkr—Nov. 2, 07. 3 figs. 2600 w. 20c. Gives details of a fan system with arrangements for internal circulation.

The Performance of Hot Blast Coils—II. Htg & Vent Mag—Nov., 07. 5 figs. 3800 w. 20c.

Hot-Water Heating.

Proportioning Radiation Hot-Water Heating. Geo. G. Bennett. Engrs Rev—Nov., 07. 2400 w. 20c.

Steam Heating.

Air Valves for Steam Heating Systems. W. H. Wakeman. Dom Engg—Nov. 9, 07. 6 figs. 2200 w. 20c.

Ventilation.

Window Leakage and its Effect on the Amount of Radiation. Burt S. Harrison. Htg & Vent Mag—Nov., 07. 5 figs. 3000 w. 20c.

HOISTING AND HANDLING MACHINERY.

Coal and Ash Handling.

An Unusual Coal and Ash Handling Equipment for a Power Station. Eng Rec—Nov. 9, 07. 2 figs. 2600 w. 20c.

Coal Conveyor.

Aerial Wire Ropeway for Conveying Coal. Engg—Oct. 25, 07. 5 figs. 800 w. 40c.

Cost of Elevating Material.

The Power Cost of Elevating Material. Walter B. Snow. Machy—Nov. 7, 07. 40c. Nov. 14. 5600 w. Nov. 21. 5000 w. 20c.

Mine Hoisting.

Report of the Transvaal Commission on the use of Winding Ropes, Safety Catches and Appliances in Mine Shafts (continued). Eng. News—Nov. 7, 07. 1 fig. 9000 w. Nov. 14, 5600 w. Nov. 21, 5000 w. Each, 20c.

Ore Handling.

Ore Handling Plant at South Bethlehem, Pa. Ir Age—Nov. 14, 07. 7 figs. 3500 w. 20c. Describes the car dumper and other features of the Bethlehem Steel Co.'s System.

HYDRAULIC POWER PLANTS.

Centrifugal Pumps.

Centrifugal Pumps. E. F. Doty. Engr—Nov. 1, 07. 8 figs. 3000 w. States a number of reasons why modern designs are more efficient. Nov. 15. 1800 w. Discusses causes of lost energy and life. Each, 20c.

Notes on Centrifugal Pumps.—I. Mech Wld—Oct. 25, 07. 4 figs. 2300 w. 20c.

Efficiency Test of Pumping Plant.

Efficiency Test of an Electric Pumping Plant. Hal. M. Hall, J. Grant de Remer, H. E. Sherman, Jr. Jl of El, P & Gas—Nov. 16, 07. 5 figs. 2500 w. 20c.

Governing of Pelton Wheels.

The Governing of Pelton Water Wheels. Herbert Aughtie. Mech Engr—Nov. 9, 07. 2 figs. 1500 w. 40c.

Hydro-Electric Plants.

Hydro-Electric Station of Pataras, on the Loup River, France. A. de Courcy. W. Elecn—Nov. 9, 07. 2 figs. 2000 w. 20c.

Hydro-Electric Generating Station on the Waipori River in New Zealand. Elec Wld—Nov. 23, 07. 7 figs. 6800 w. 20c.

The Necaxa, Mexico, Power Works. Engr (Lond)—Nov. 8, 07. 10 figs. 3900 w. 40c. I.—The Dams and Channels.

The Hydro-Electric Development in the St. Mary's River at Sault Ste Marie, Mich. Eng Rec—Nov. 2, 07. 10 figs. 4600 w. 20c.

Miner's Inch.

Calibrations of Various Miner's Inch Openings. Kent A. Hawley. Jl Elec Pow & Gas—Nov. 2, 07. 2 figs. 2900 w. 20c.

South American Waterfalls.

Water Possibilities in South America. Lewis R. Freeman. Power—Nov., 07. 7 figs. 4200 w. 60c. Describes numerous waterfalls which make the country ideal for projects for electrical generation, of which several are now under way.

...dal Power.

...wer From Tides. William O. Webber. Nov. 1, 07. 3 figs. 1000 w. 20c.

INTERNAL-COMBUSTION ENGINES.

Gas and Gasoline Engines.

A Fan Fly-wheel for Gasoline Engines. E. J. Bartlett. Am Mach—Nov. 21, 07. 3 figs. 1200 w. 20c.

A Study of the Heat-Losses in a Gasoline Engine. Arthur J. Wood. Stevens Inst Ind —Oct., 07. 2 figs. 4200 w. 80c.

On the Indicated Power and Mechanical Efficiency of the Gas Engine. Bertram Hopkinson. Engg—Oct. 25, 07. 7 figs. 8000 w. Paper read before the Institute of Mechanical Engineers, Oct. 18, 07

Gas-Power Plants.

A Buenos Aires Power Plant. J. P. Stone. Gas Engine—Oct., 07. 4 figs. 3500 w. 20c. Describes a large producer installation used in railway shops.

A Diesel Engine Power Station. J. B. Van Brussel. Jl El P & Gas—Nov. 2, 07. 3 figs. 2200 w. 20c. Describes a 500-HP. storage battery plant at Friedenau, near Berlin.

Ignition.

Concerning the Progress of Ignition. Charles B. Hayward. Automobile—Nov. 21, 07. 18 figs. 3600 w. 20c. Describes a number of new igniters.

Producer Gas.

Test of a Producer Gas Plant. J. H. Alexander. Engr—Nov. 1, 07. 3000 w. 20c. Gives efficiencies of a 200-HP. plant, first cost and cost of operation.

MACHINE PARTS.

Ball and Roller Bearings.

Ball Bearings (continued). Mech Wld—Oct. 28, 07. 9 figs. 1200 w. Nov. 15. 8 figs. 1400 w. Each, 20c.

Ball Bearings in a Marble Plant. Charles Gullet. Am Mach—Nov. 7, 07. 5 figs. 4500 w. 20c. Describes the use of ball bearings in marble machinery in spite of dust and unskilled attendance.

Progress with Ball and Roller Bearings. S. F. Eveland and Henry Hess. Am Mach—Nov. 7, 07. 2700 w. 20c. States what has been learned and done in substituting rolling for sliding friction, and in increasing the loads carried.

Bearings.

Hot Bearings. E. Kistinger. Machy—Nov., 07. 11 figs. 2000 w. 40c.

Improved Forms of Machine Parts. C. Volk. Z V D I—Nov. 9, 07. 48 figs. 2500 w. 60c. Describes new forms of bearings, hangers, loose pulleys and shaft couplings.

Largest Anti-Friction Thrust Bearing Ever Made. Am Mach—Nov. 7, 07. 6 figs. 3900 w. 40c. Describes the design, construction and test of a roller thrust bearin carrying a load of 150,000 lbs.

Chain Drive.

What Has Been Done in Chain Driving. F. L. Morse. Am Mach—Nov. 7, 07. 1 fig. 2000 w. 20c.

Crane Hooks.

Notes on Boat and Anchor Cranes.—II. Inter Mar Engg—Dec., 07. 5 figs. 700 w. 40c.

Friction Clutches.

Friction Clutches vs. Tight and Loose Pulleys. Engr—Nov. 1, 07. 2 figs. 600 w. 20c.

Gearing.

Driving Mechanism for Machine Tools. T. M. Lowthian. Am Mach—Nov. 14, 07. 5 figs. 1000 w. 20c.

The Yieldable Gear. Ir Age—Nov. 7, 07. 2 figs. 500 w. 20c.

Shafts.

Empirical Formulas for Gas Engine Shafts. Am Mach—Nov. 14, 07. 700 w. 20c.

Speed-Changing Mechanism.

A new Gearless Change-Speed Mechanism. Ernest Coler. Automobile—Nov. 14, 07. 4 figs. 1100 w. 20c.

Stay Bolts.

Safe Loads on Staybolts. George P. Pearce. Engr—Nov. 15, 07. 500 w. 20c.

MATERIALS.

Alloy Steels.

Some Micro-Structural Considerations. John Magee Ellsworth and Thomas J. Fay. Automobile—Oct. 17, 07. 2 figs. 4300 w. 20c. Extract from paper read before Society of Automobile Engineers, Buffalo, July, 1907. Discusses the micrography of a number of alloy steels used in automobile construction.

Lubricants.

Lubricating Oil Specifications. Ry & Eng Rev—Nov. 2, 07. 1000 w. 20c. Gives specifications adopted by the Bureau of Steam Engineering of the Navy Department.

Steel for Boilers.

Steel Used in Boilers. Am Mach—Nov. 14, 07. 2 figs. 2200 w. 20c. Abstracts from addresses at the American Boiler Makers' Association, nineteenth annual convention.

Testing Machines.

An Instrument for Testing Hardness. Albert F. Shore. Am Mach—Nov. 14, 07. 5 figs. 4300 w. 20c. Describes the scleroscope, an instrument that establishes a scale for hardness and determines the relative and quantitative hardness of all metals.

New Machines and Methods for Testing ill. Rev. d Mec—Oct., 07. $1.80.

MECHANICS.

Deflection of Beam of Non-Uniform Section.

The Deflection of a Beam of a Non-Uniform Section. Eng News—Nov. 14, 07. 4 figs. 4500 w. 20c. Gives a number of solutions presented by correspondents.

Principles.

The True Principles of Mechanics. Sidney A. Reeve. Engr—Oct. 25, 07. 2300 w. 40c. Points out that the ordinary formulas for the fundamental mechanical principles are erroneous approximations.

METAL WORKING.

Armor Plate Vault.

A Record-Breaking Armor-Plate Vault. Machy—Nov., 07. 7 figs. 2100 w. 40c. Gives details of a vault for the Carnegie Safe Deposit Co.

Brazing.

The Brazing and Reinforced Brazing of Metals. Am Mach—Nov. 7, 07. 14 figs. 3900 w. 20c. Describes examples with and without reinforcement for permanent repairs on parts of different sizes and metals also for new work.

Chuck.

Machining a Chuck Body. G. H. Gibbs. Mech Wld—Nov. 8, 07. 18 figs. 3500 w. 20c.

File Making.

Recent Improvements in File Making. Ry & Engg Rev—Nov. 2, 07. 2 figs. 1200 w. 20c.

Galvanizing.

Old and New Methods of Galvanizing. Alfred Sang. Proc Engrs Soc of W Penn—Nov., 07. 6200 w. 80c. From a paper read before the Am. Chem. Society and the Engrs.' Society of W. Penn., Oct. 17, 07.

Grinding.

Economies and Advantages of Grinding. H. Darbyshire. Am Mach—Oct. 24, 07. 8 figs. 3700 w. 20c. Describes the selection of proper wheels, keeping them in good condition and using them at the right pressure and speed.

Some Grinding Problems. H. Darbyshire. Engg—Nov. 15, 07. 8 figs. 6800 w. 40c.

High-Speed Steel Tools.

Actual Results with High-Speed Steel. Fred H. Colvin. Am Mach—Nov. 7, 07. 2500 w. 20c. Gives information obtained from many of the shops using this steel.

Jigs.

Locating and Boring Holes in Drill Jigs.—I. C. L. Goodrich. Am Mach—Nov. 21, 07. 11 figs. 4900 w. 20c. Discusses the lay-out of jigs and the location of holes by buttons, micrometers and verniers for boring on the lathe and miller.

Lapping.

Lapping Flat Work and Gage Jaws. F. E. Shailor. Machy—Nov., 07. 8 figs. 28[illegible] w. 40c.

Lathe and Planer Tools.

Standard Shapes for Cutting Tools. Wm. H. Taylor. Am Mach—Nov. 7, 07. 31 figs. 5500 w. Nov. 14. 34 figs. 8500 w. Nov. 21. 16 figs. 6200 w. Each, 20c. Gives detailed instructions for forging and grinding tools according to F. W. Taylor's standard shapes and sizes.

Power for Machine Tools.

Horse-Power Values for Machine Tools. L. P. Alford. Am Mach—Nov. 14, 07. 6 figs. 1500 w. 20c. Discusses the percentages of friction loads for machine-tool departments and losses by electrical driving, and gives department power curves.

Reamers.

Reamers. Erik Oberg. Machy—Nov., 07. 6 figs. 4200 w. 40c. IV.—Taper Reamers.

Spiral Gear Cutting.

Compound Indexing for Cutting Spiral Gears. Clinton Alvord. Am Mach—Nov. 14, 07. 1 fig. 600 w. 20c.

Swaging.

A New Method of Shaping Metals. Am Mach—Nov. 7, 07. 8 figs. 2500 w. 20c. Describes a process of roll and hammer swaging which produces rapid and accurate work without the loss of material.

Tank Layout.

Laying Out the Sheets of a Large Tank. Eng News—2 figs. 1200 w. 20c.

Wire-Drawing Machines.

Modern Practice in Wire Drawing Machines.—II. Engg—Nov. 1, 07. 24 figs. 3500 w. 40c.

REFRIGERATION.

Cooling Rooms.

Cooling Public Rooms in a Chicago Hotel. Ice & Refrig—Oct., 07. 4 figs. 4100 w. 40c. Gives a detailed description of air-cooling and ventilating plant for the Pompeian Room and banqueting hall in the Auditorium Annex at Chicago, having an automatic regulation of air supply, the temperature in open rooms being reduced 14° below that of outer air.

Cold Storage.

The Mechanical Equipment of the North American Cold-Storage Building, Chicago. Eng Rec—Nov. 16, 07. 3 figs. 3300 w. 20c.

Ice Manufacture.

Compression Plants Using Ammonia as the Refrigerant. Thomas Shipley. Cld Stor & Ice Tr Jl—Nov., 07. 3800 w. 40c. Paper read at the National meeting of Ice Producers, Jamestown, Oct. 28, 07.

Laying Up an Ice Plant. William S. [illegible] —Nov. 1, 07. 3 figs. 4100 [illegible] overhauling of ma- [illegible] the busy season has

The Manufacture of Plate Ice. Karl Wegemann. Cld Stor & Ice Tr Jl—Nov., 07. 2100 w. 40c. Paper read before the Eastern Ice Assn., Philadelphia, Nov. 8, 07.

The Vacuum Ice Machine. John Patten. Cld Stor & Ice Tr Jl—Nov., 07. 1 fig. 4200 w. 40c. Paper read before the Eastern Ice Assn., Philadelphia, Nov. 8, 07.

Refrigeration.

Pipe Line Refrigeration. R. H. Tait. Cld Stor & Ice Tr Jl—Nov. 07. 2000 w. 40c Paper read at the National meeting of Ice Producers., Jamestown, Oct. 28, 07.

Refrigeration.—I. Sydney F. Walker. Mech Wld—Nov. 15, 07. 4 figs. 3000 w. 20c.

SHOPS AND BUILDINGS.

Jig and Tool Department.

The Organization of a Jig and Tool Department. John Younger. Engg—Oct. 25, 07. 1 fig. 1400 w. 40c.

Machine Shop.

The Machine Shop; Its Place in the Plant. Oscar E. Perrigo. Iron Tr Rev—Nov. 7, 07. 7 figs. 3600 w. 20c.

Pattern Shop.

Location of the Pattern Shop. Oscar E. Perrigo. Fdry—Nov., 07. 5 figs. 2900 w. 20c. First of a series of articles relating to the operation and management of the pattern shop.

STEAM POWER PLANTS.

Boiler Blow-Off.

Boiler Blow-Off Connections. R. T. Strohm. El Wld—Nov. 2, 07. 11 figs. 2500 w. 20c.

Cooling Towers.

Cooling Towers. B. Franklin Hart, Jr. Cld Stor & Ice Tr Jl—Nov., 07. 2600 w. 40c. Paper read before the Eastern Ice Assn., Philadelphia, Nov. 8, 07.

Energy Diagram for Steam.

A New Energy Diagram for Steam. Henry F. Schmidt. El Ry Rev—Oct. 19, 07. 1 fig. 2700 w. 20c. Gives explanation of a novel and effective diagram of wide application in the solution of heat problems.

Engine Failures.

Engine Failures. J. F. Whiteford. Am Engr & R R Jl—Nov., 07. 2600 w. 40c.

Governor.

The Deflection of Rotary Helical (Governor) Springs Due to Centrifugal Force. J. Luttmans. Z V D I—Nov. 9, 07. 1 fig. 3000 w. 60c.

Heat Radiation.

The Practical Engineering Importance of Stefan and Boltzmann's Radiation Law, Engg—Nov. 1, 07. 1100 w. 40c.

Reversing Apparatus for Rolling Mill Engine.

Steam Reversing Apparatus for a Twelve Thousand Horse-power Rolling-mill Engine. Am Mach—Nov. 14, 07. 1 fig. 600 w. 20c.

Power Plants.

Power Plant of the Pittsburg & Butler Street Railway Company. H. C. Reagan. Engr—Nov. 1, 07. 6 figs. 4600 w. 20c. Describes a turbine plant and a single-phase system of transmission.

Remodeled Station of the Watertown Light and Power Company. El Wld—Nov. 2, 07. 7 figs. 2600 w. 20c.

South Metropolitan (London) Power Station. Albert H. Bridge. El Rev—Nov. 9, 07. 7 figs. 2500 w. 20c.

Steam-Driven Transmission Stations of the Societa Lombara, of Milan, Italy. Elec Wld—Nov. 9, 07. 4 figs. 3000 w. 20c.

The Hochelaga Power Station of the Montreal Street Railway Company. St Ry Jl—Nov. 9, 07. 13 figs. 4200 w. 20c.

Steam Turbines.

Steam Turbine Construction. I. T. Franklin. Mech Wld—Nov. 1, 07. 7 figs. 2400 w. 20c.

The Development of Turbines Operating Exhaust Steam. A. Rateau. Rev d Mec—Oct., 07. 27 figs. $1.80.

The Sturtevant Steam Turbine. Eng News—Oct. 31, 07. 5 figs. 2300 w. 20c. Describes a novel design for use in driving small generators, high-speed pumps and blowers.

METALLURGY

COKE.

A Battery of Belgian Type Coke Ovens. Ir Tr Rev—Nov. 14, 07. 13 figs. 3300 w. 20c. Describes a new departure in coke making in the Connellsville field.

Coke Drawing Machines and Other Machinery for Use at the Ovens in the Manufacture of Coke. Walter W. Macfarren. Proc Engrs Soc of W Penn—Nov., 07. 27 figs. 16,500 w. 80c. Paper read before Engineers' Society of Western Pennsylva Oct. 1, 07.

COPPER.

Electrolytic Refining.

Metallurgical Calculations. Jos. W. Richards. Electrochem & Met Ind—Nov., 07. 6400 w. 40c. IV. Electrolytic refining of impure copper.

Smelting.

Copper Smelting in Utah. Robert B. Brinsmade. Mines & Min—Nov., 07. 6 [illegible] w. 40c. Describes the practice [illegible] nsolidated, the Bingham Con- [illegible] he Yampa smelters.

Furnace-Charging. G. F. Beardsley. Min & Sc Pr—Nov. 9, 07. 1500 w. 20c.

The Steptoe Valley Mill and Smelter. Walter Ingalls. Eng & Min Jl—Nov. 2, 07. 6 figs. 4400 w. 20c. Describes a concentrating mill of 4000 tons daily capacity and a 1000-ton smelter, with McDougall roasters and three reverberatories.

GOLD.

Cyaniding.

The Cyanide Process at the Portland (Colo.) Mill. Regis Chauvenet. Min Rep—Oct. 31, 07. 3500 w. 20c.

IRON AND STEEL.

Electric Furnace.

The Hiorth Electric Furnace. Min Jl—Oct. 26, 07. 1800 w. 40c.

Pig Iron, Metallography of.

The Metallography of Pig Iron. E. Heyn and O. Bauer. Stahl u Eisen—Oct. 30, 07. 27 figs. 4500 w. Nov. 6, 07. 6 figs. 3500 w. Each, 60c.

Steel Manufacture.

Mechanical Contrivances for Use in Steel Works. I. Fr Frölich. Z V D I—Nov. 2, 07. 38 figs. 5000 w. 60c. Describes cars for the transportation of molten metal from converters.

The Duplex Steel Making Process. B. C. Lauth. Ir Age—Nov. 21, 07. 2 figs. 2400 w. 20c. Discusses a proposed arrangement of plant for making Bessemer and open-hearth rails.

The Lash Steel Process and The Electric Furnace. Electrochem & Met Ind—Nov., 07. 1600 w. 40c.

Steel Mill.

New Saucon Plant of Bethlehem Steel Co. Ir Tr Rev—Nov. 7, 07. 13 figs. 5400 w. 20c. Gives details of the new 28-inch rail mill, structural mill, and beam mill.

Steel Rails.

Steel Rails. Franklin E. Abbott. Ry & Eng Rev—Nov. 16, 07. 10,000 w. 20c. Extract from a paper describing the manufacture of Bessemer rails, presented at a meeting of the Central Railway Club, Buffalo, N. Y., Nov. 8, 07.

Steel Rails, Their Mechanical Treatment, Past and Present. S. T. Fiero. Ind Wld—Nov. 11, 07. 1 fig. 5500 w. 20c.

SILVER.

Smelter Analysis.

"Silica" and "Insoluble" in Smelter Analysis. E. Kneeland. Eng & Min Jl—Nov. 2, 07. 500 w. 20c.

ZINC.

Electrometallurgy.

Application of Electricity to Smelting Zinc. Frederick T. Snyder. Min Wld—Nov. 9, 07. 2000 w. 20c.

The Electrolytic Precipitation of Metallic Zinc by Electrolysis of Sulphate of Zinc Solutions. Siemens & Halske. Min Jl—Oct. 26, 07. 500 w. 40c.

The Electrometallurgy of Zinc. Gustav Gin. Elec Rev—Nov. 2, 07. 2300 w. 20c. Abstract of a paper read before the American Electrochemical Society, New York, Oct. 18, 07.

Milling.

Improvements in Milling Missouri Zinc Ores. W. E. Ford. Eng & Min Jl—Nov. 9, 07. 4000 w. 20c. Discusses whether or not it would pay to treat further the mineral discarded in the tailings.

Sludge-Mill Practice in the Missouri-Kansas District. Otto Ruhl. Min Rep—Nov. 7, 07. 4 figs. 2600 w. 20c.

Smelting.

History of Smelting in the Joplin District. Doss Brittain. Eng & Min Jl—Nov. 9, 07. 8 figs. 8300 w. 20c.

MINING ENGINEERING

Asbestos.

Asbestos Mining & Milling in Quebec.—II. Ralph Stokes. Min Wld—Nov. 2, 07. 5 figs. 3900 w. 20c.

Cadmium.

Cadmium. Paul Speier. Min Jl—Nov. 9, 07. 3100 w. 40c. Discusses its occurrence and industrial uses.

Coal.

A Modern Retail Coal Pocket. Charles J. Steffens. Eng Rec—Nov. 2, 07. 2 figs. 4600 w. 20c.

Coal Mining in Southern West Virginia. Floyd W. Parsons. Eng & Min Jl—Nov. 9, 07. 7 figs. 3400 w. 20c. Discusses a field yielding steam coal of superior quality.

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Copper.

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Gas Power as a Factor in Mine Economics. Archibald Burnett. Eng & Min Jl—Nov. 16, 07. 3 figs. 2900 w. 20c.

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An Electrically Equipped Lead Mine. Henry Flow. Eng News—Nov. 14, 07. 7 figs. 3000 w. 20c.

Mine Gases.

Mine Gases and Methods of Preventing Explosions. H. E. Gray. Engg & Min Jl—Oct. 26, 07. 4400 w. 20c. Discusses the various gases found in coal mines, together with methods of identification and means for preventing accidents.

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Mine Surveying.

A Method of Mine Surveying. Can Min Jl—Nov. 15, 07. 2400 w. 40c. Describes method of instrumental work and preserving of notes.

Mine Timbers.

Prolonging the Life of Mine Timbers. John M. Nelson, Jr. Min Rep—Nov. 7, 07. 1 fig. 2000 w. 20c.

Nickel.

The Occurrence of Nickel in Virginia. Thomas Leonard Watson. Trans Am Ins Min Engrs—Sept., 07. 4 figs. 5000 w. $2.00. Paper read at the Toronto meeting, July, 1907.

Ore Crushing.

Economy of Power in Crushing Ore. Ernest A. Hersam. Min & Sc Pr—Nov. 16, 07. 9400 w. 20c.

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Sheet-Ground Mine in Southwest Missouri. D. T. Boardman. Eng & Min Jl—Nov. 9, 07. 4 figs. 4000 w. 20c.

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Requirements for Treating Wood Paving Blocks. Geo. W. Tillson. Eng Rec—Nov. 16, 07. 4600 w. 20c. Paper read before Am. Soc. of Municipal Improvements.

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The Prevention of Stream Pollution by Strawboard Waste. Earl B. Phelps. Tech Quarterly—Sept., 07. 6 figs. 7600 w. 80c.

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Punishment for Waste of Well Water in California. Eng Rec—Nov. 9, 07. 3 figs. 3600 w. 20c.

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The Southern Railway's Freight Yards at Atlanta, Ga. Eng News—Nov. 7, 07. 3 figs. 2000 w. 20c.

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New Locomotives for New York, Chicago & St. Louis R. R. Ry Age—Nov. 16, 07. 3 figs. 2000 w. 20c.

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The Hayden Locomotive Stoker. Ry Age —Nov. 8, 07. 4 figs. 1700 w. 20c. Describes a stoker provided with a conveyor which delivers the coal from a tender to the hopper at the fire door and forces the coal into a fire-box by means of a steam jet.

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Steel Ties in Germany. Dr. N. C. A. Haarmann. Ir Tr Rev—Nov. 7, 07. 3 figs. 2000 w. 20c.

Track Construction and Corrugation: Philadelphia and Boston Experiences. Tram & Ry Wld—Oct. 3, 07. 17 figs. 7300 w. 40c.

Why Efficient Track Work is Skilled Labor. W. M. Camp. Ry Eng Rev—Nov. 16, 07. 3400 w. 20c. Paper read at the annual convention of the Roadmasters' and Maintenance of Way Association, Chicago, Nov. 14, 07.

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Peoria Station of the Illinois Traction System. Engr—Nov. 15, 07. 15 figs. 5000 w. 40 c. Describes a station equipped with steam turbines, water-tube boilers and mechanical stokers.

The Spy Run Station of the Fort Wayne & Wabash Traction Co. Eng Rec—Nov. 23, 07. 4 figs. 4800 w. 20c.

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Comparative Performance of Steam and Electric Locomotives. Albert H. Armstrong. Proc Am Inst E E—Nov. 8, 07. 16 figs. 14,300 w. 80c. A paper read before the Am. Inst. of Elec. Engrs., Nov. 8, 07.

Track.

Concrete in Street Railway Construction. George D. Steele. Cem Era—Nov., 07. 5 figs. 1800 w. 20c.

Rehabilitating the Tracks of the Chicago City Railway. St Ry Jl—Oct. 26, 07. 4 figs. 4100 w. 20c. Describes the track reconstruction now being carried on.

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Engineering-Contracting, Chicago.
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Engineering Record, New York.
Industrial Magazine, Park Row Bldg., New York.
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Rife Hydraulic Ram Co., R. 2160 Trinity B., New York.

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India Rubber & G. P. Ins. Co., 253 Broadway, New York.

Technical Literature is Mailed Flat

Did you ever see anyone opening a trade journal—or rather trying to open one?

Better yet, did you ever try to open one yourself?

The average trade-journal publisher thinks he has fulfilled his contract to advertisers and subscribers when he ships his paper out of the printing house wound up by some machine with the power of a cotton-compress.

It requires the best mechanic about a place to open a trade paper with grace and Christian fortitude, and without injury to himself or the journal.

The average man will take a letter-opener, or a hat or hair-pin, borrowed from a stenographer, jab at the wrapper and worry off a piece big as postage-stamp per jab. Before he gets half way across the package, he will utter a reversed prayer in lieu of dust to dust and ashes to ashes, and throw it where the office-boy puts the catalogues and other third-class mail.

Then if you do get enough of the wrapper off so that it—well, it never comes open—it flies open.

To see a man trying to open one of these manila hide-bound trade journals and watch it fly up is to be reminded of trying to wind a Waterbury watch, which usually lets go and covers the winder with five-and-seventy feet of narrow steel ribbon—like somebody had dumped a waste-basket full of ticker tape on him.

It requires a hydraulic press to get the average trade-journal in a lying position for any length of time.

If an industrial concern received a package of goods that they could not open without injury to said goods, they would throw it back on the shipper's hands.

With the average trade-journal, you must take 'em as you find 'em.

It's a good deal like the Irishman who ordered a steak in a cheap restaurant patronized by his countrymen:

"I won't pay for this steak," said the eater.

"You will," said the waiter.

"Why will I, when I can't cut it, let alone eat it?" returned the Irishman.

"Well, but you've bent it," said the waiter. —David Gibson in "The Silent Partner."

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